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United States Patent [19]

Flamme

[11] **Patent Number: 6,024,035**

[45] **Date of Patent: Feb. 15, 2000**

[54] **SEED PLANTING RATE MAINTENANCE CONTROL WITH RATE DISPLAY**

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[73] Assignee: **Case Corporation**, Racine, Wis.

[21] Appl. No.: **08/935,759**

[22] Filed: **Sep. 23, 1997**

[51] **Int. Cl.**^{7} **A01C 7/00**

[52] **U.S. Cl.** **111/178**; 111/181; 111/904; 250/222.2; 222/624; 221/13

[58] **Field of Search** 111/178, 181, 111/188, 179, 900, 903, 904, 200, 17, 19, 118; 701/50; 390/674; 250/222.2; 221/13, 2; 222/614, 624, 626

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Primary Examiner—Victor Batson
Attorney, Agent, or Firm—Foley & Lardner

[57] **ABSTRACT**

A seed planter performance monitor is disclosed herein. The monitor is used with a planting system including a planter coupled to the tractor. The target rate at which the planter deposits seeds into the soil being planted is controlled with a control signal, and the actual rate at which seeds are planted is monitored with an infrared seed sensor supported by the planter at the location where seeds exit the planter. The planter and tractor both include data busses, and the signal from the seed sensor is transmitted to a controller on the tractor via the busses. The controller applies an appropriate signal to an electronic display in the cab of the tractor to produce an image thereon which an operator can view to determine the actual rate at which seeds are planted. The operator compares the target and the actual planting rates, and adjusts or controls the planter to place the rates in general correspondence by varying planter parameters such as air flow or pressure in the planter, or brush spacing in the drum of the seed meter.

25 Claims, 20 Drawing Sheets

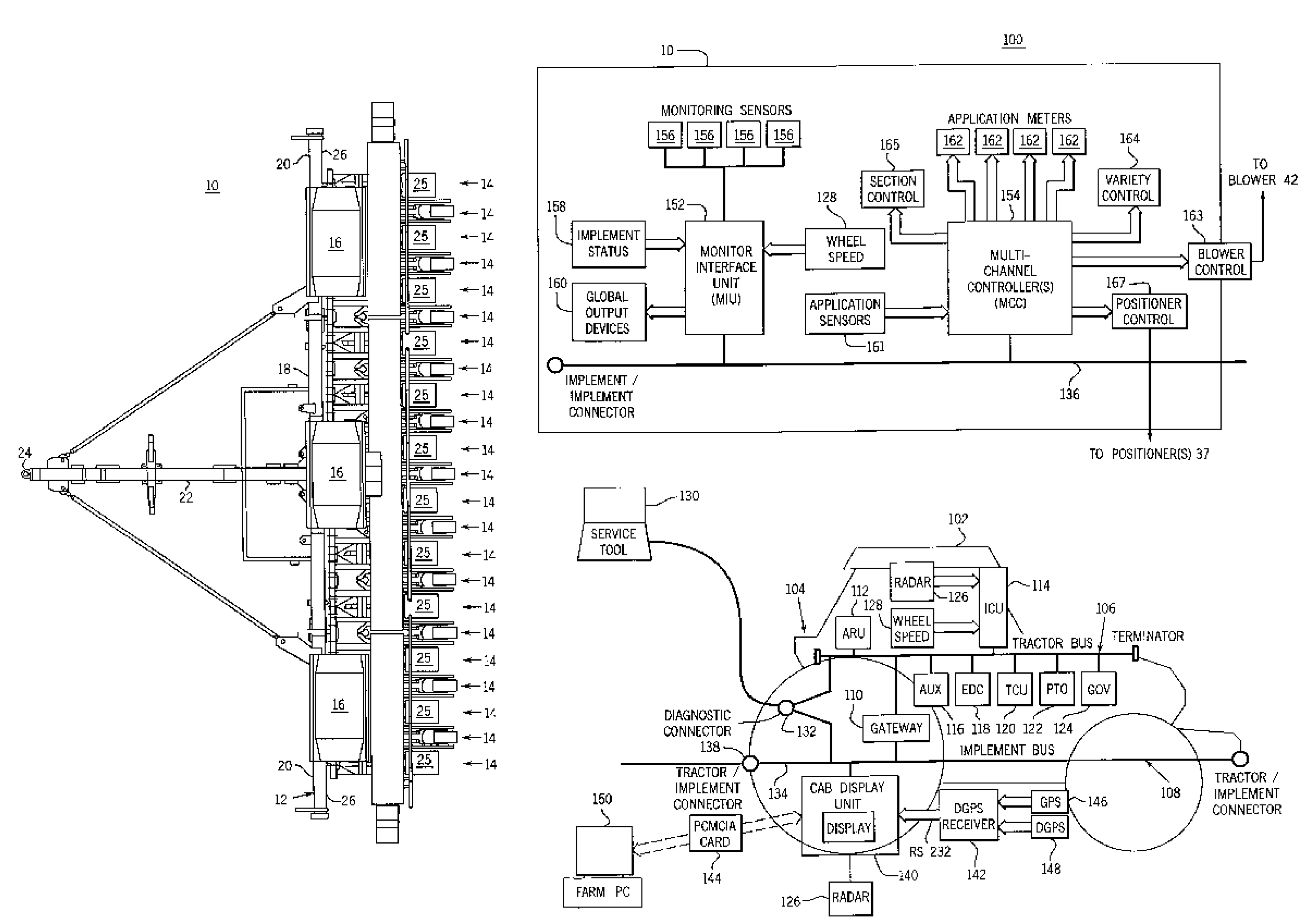

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FIG. 1

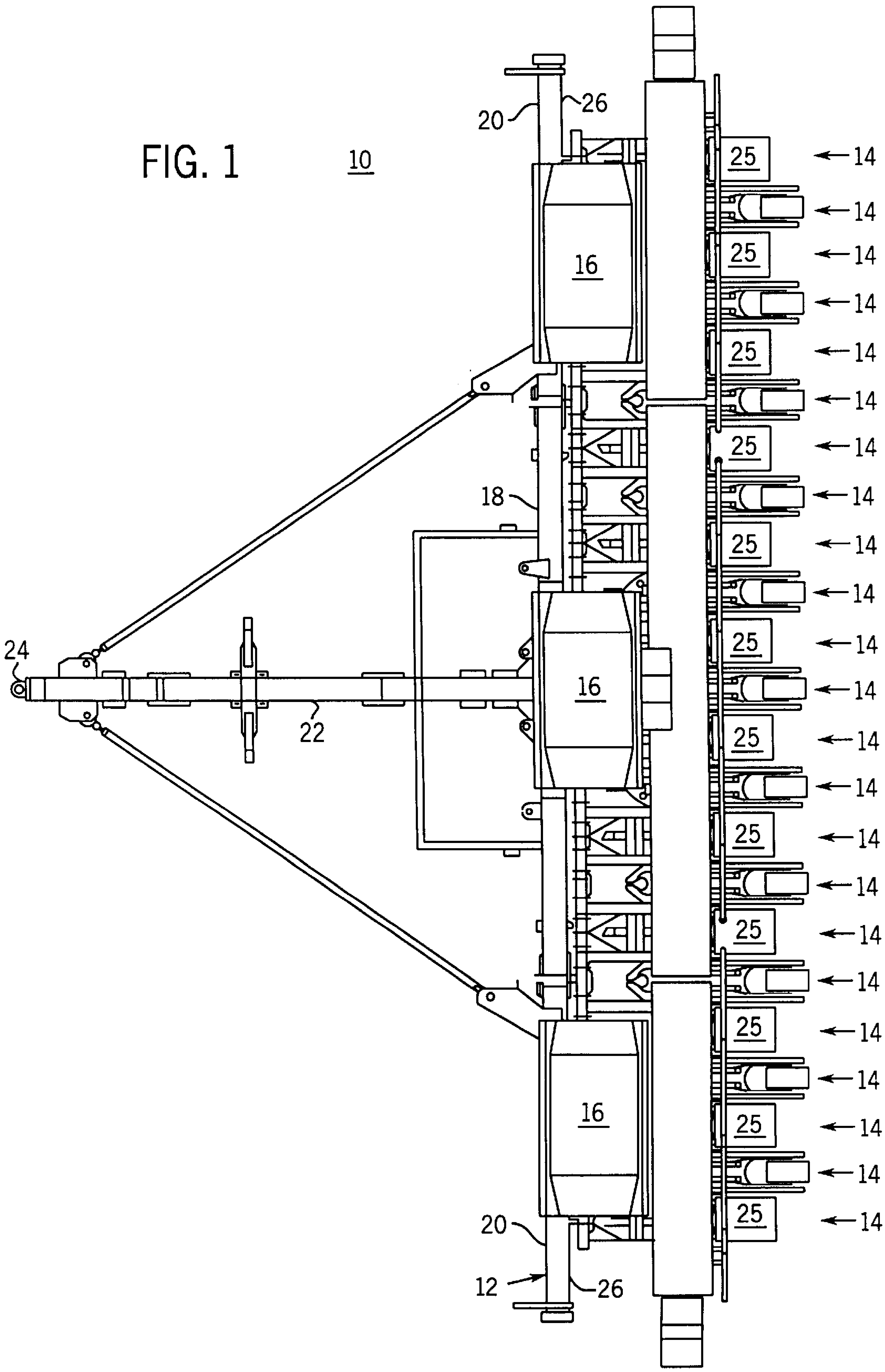
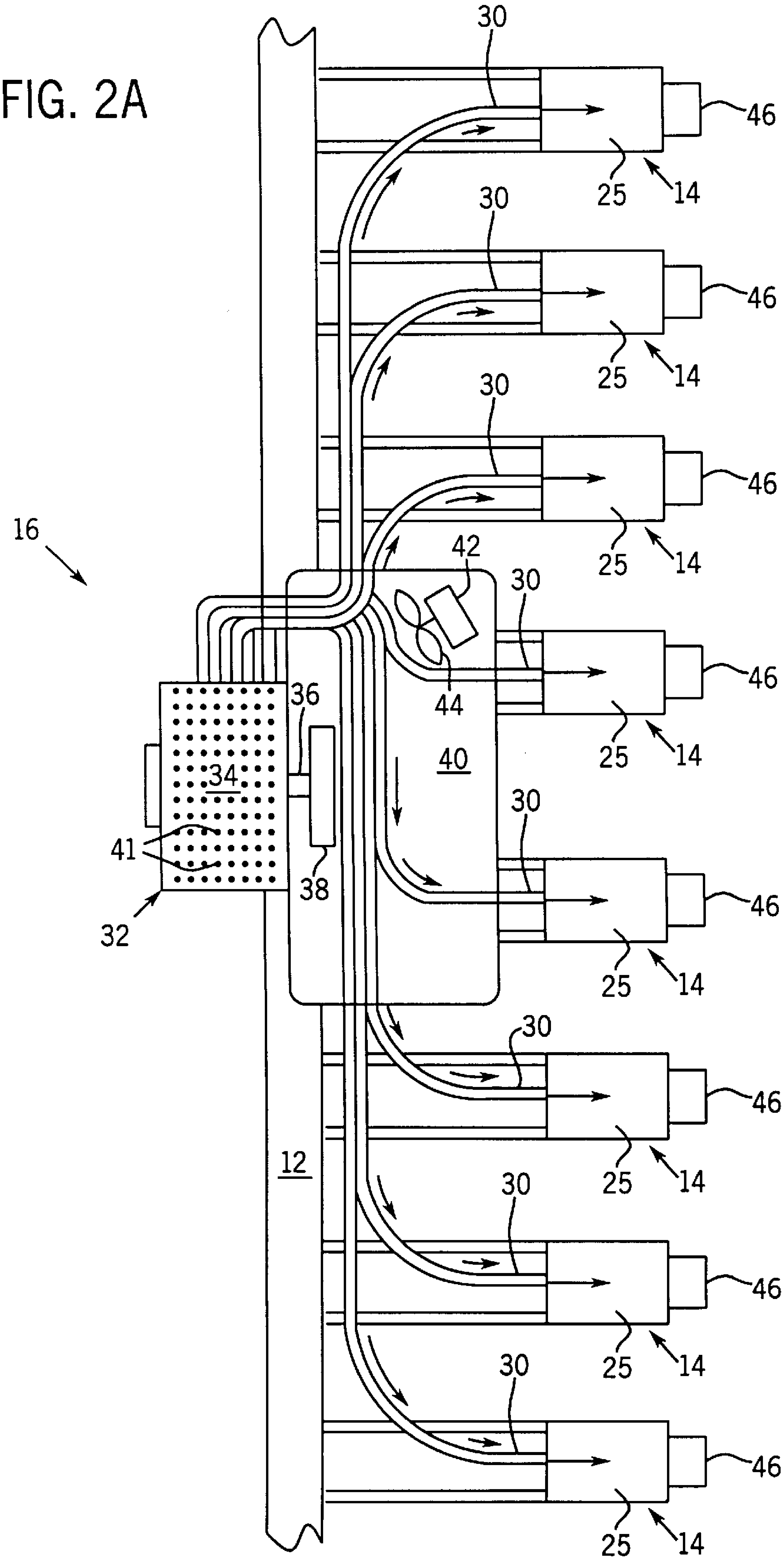


FIG. 2A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46
25
14
30
46
25
14
30
46
25
14
16
42
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46
44
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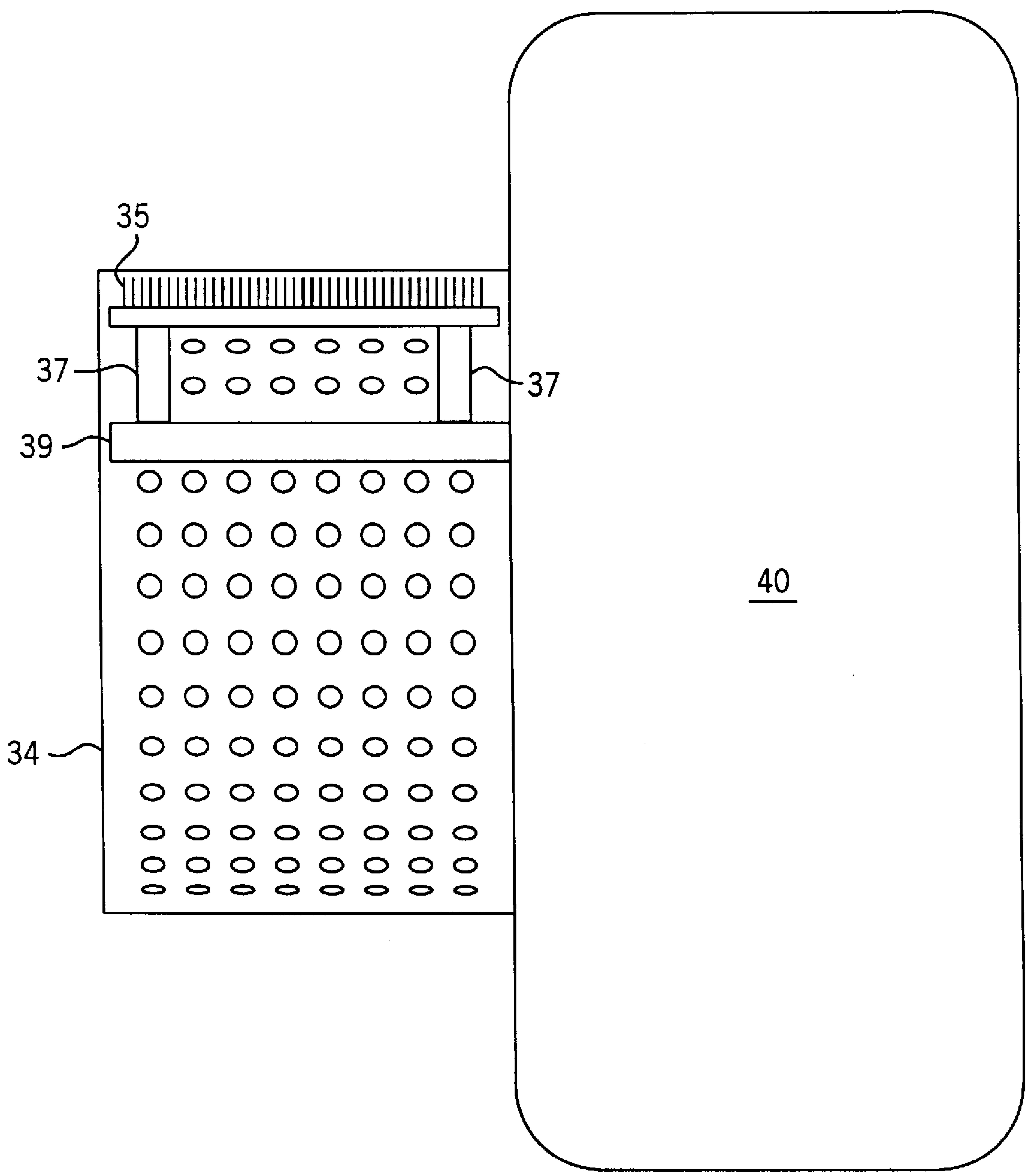
14
36
34
40
41
38
30
46
32
25
14
30
46
25
14
12
30
46
25
14
30
46
25
14

FIG. 2B



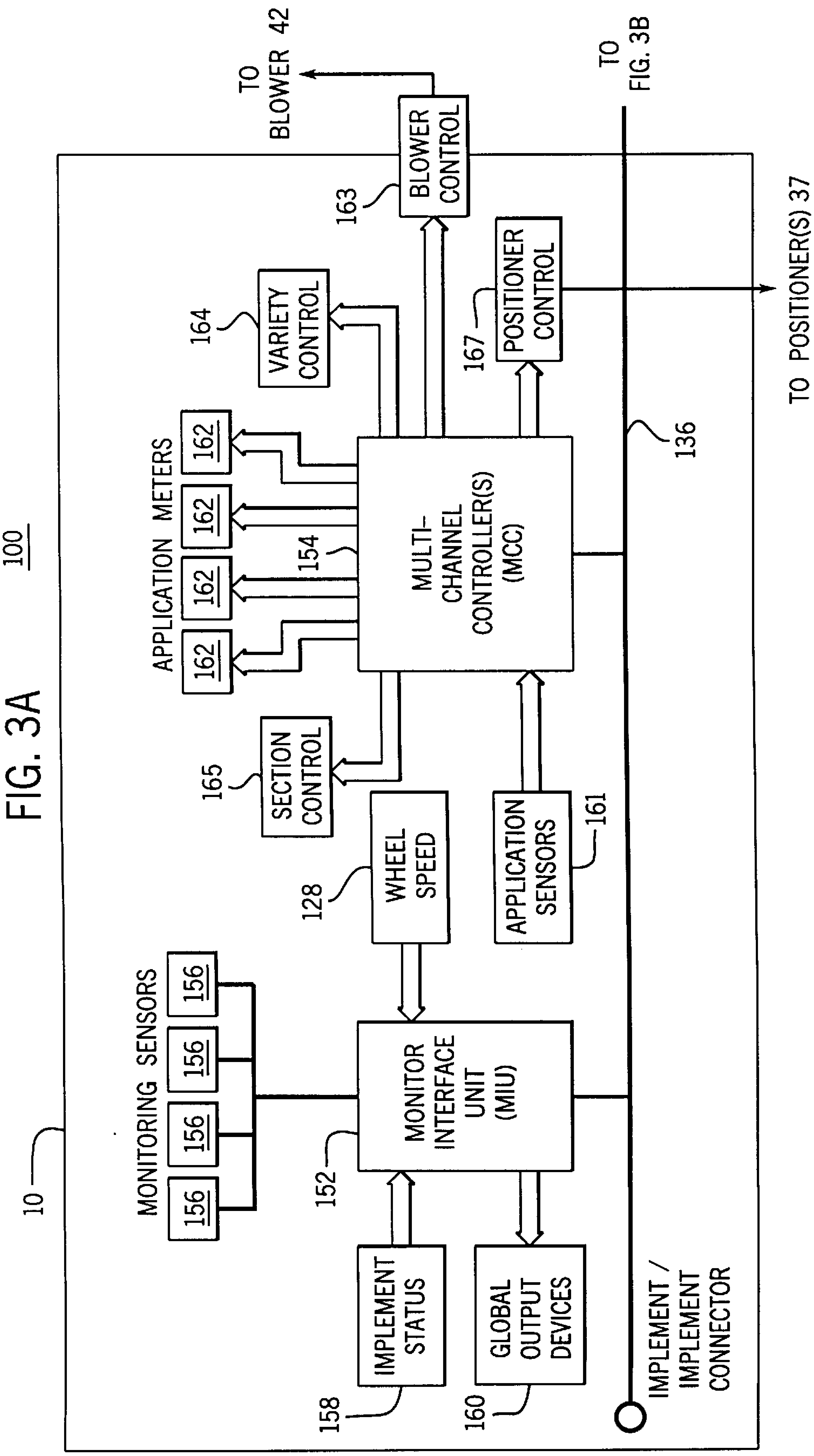

100
10
TO BLOWER 42
BLOWER CONTROL
163
TO FIG. 3B
VARIETY CONTROL
164
POSITIONER CONTROL
167
TO POSITIONER(S) 37
APPLICATION METERS
162
162
162
162
154
MULTI-CHANNEL CONTROLLER(S) (MCC)
136
SECTION CONTROL
165
WHEEL SPEED
128
APPLICATION SENSORS
161
MONITORING SENSORS
156
156
156
156
MONITOR INTERFACE UNIT (MIU)
152
IMPLEMENT STATUS
158
GLOBAL OUTPUT DEVICES
160
IMPLEMENT / IMPLEMENT CONNECTOR

FIG. 3A

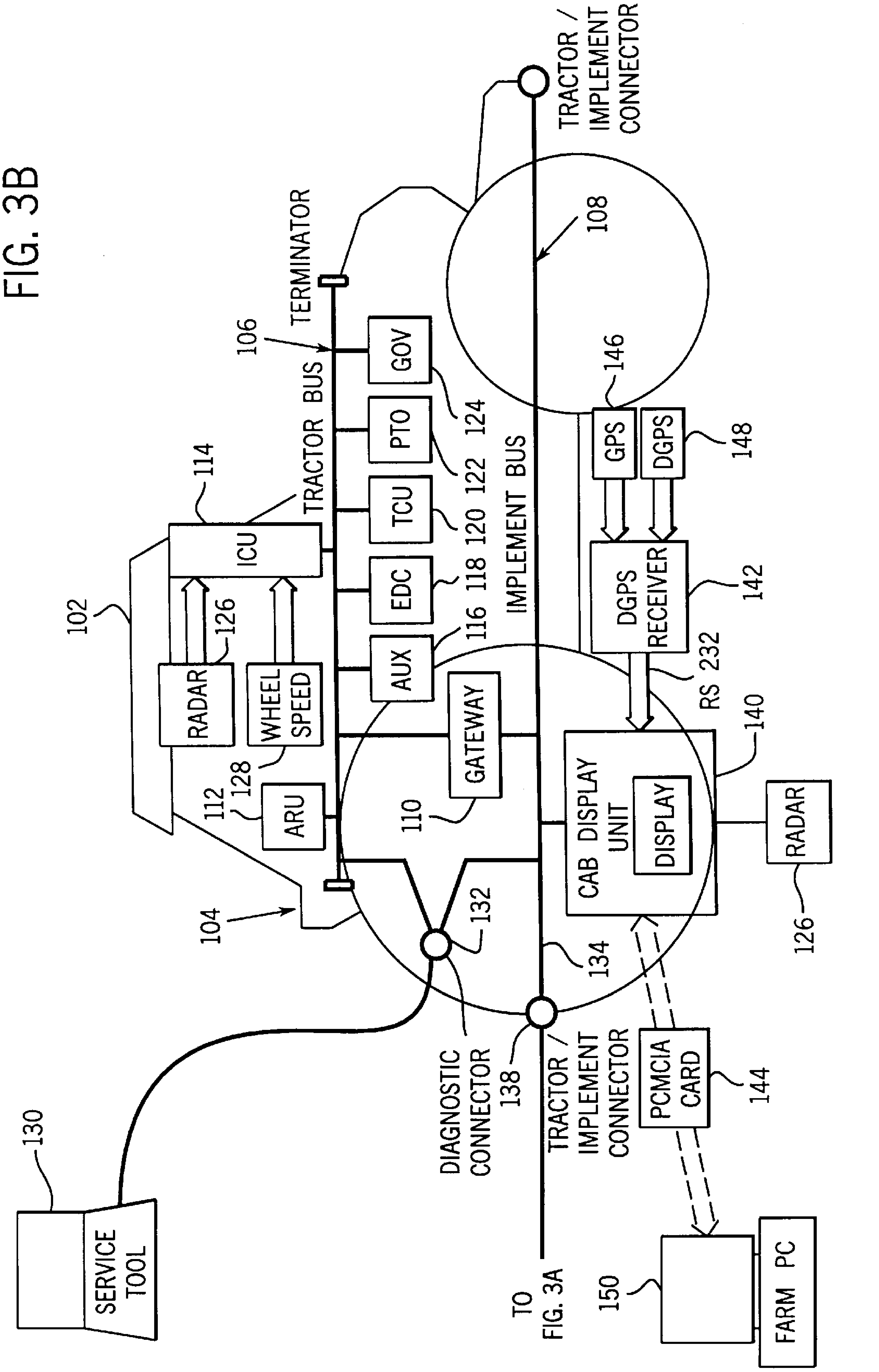

TRACTOR / IMPLEMENT CONNECTOR
108
TERMINATOR
106
TRACTOR BUS
GOV
PTO
TCU
EDC
AUX
124
122
120
118
116
114
ICU
102
126
RADAR
WHEEL SPEED
128
112
ARU
104
110
GATEWAY
IMPLEMENT BUS
146
GPS
DGPS
148
DGPS RECEIVER
142
RS 232
140
CAB DISPLAY UNIT
DISPLAY
RADAR
126
132
134
DIAGNOSTIC CONNECTOR
138
TRACTOR / IMPLEMENT CONNECTOR
PCMCIA CARD
144
130
SERVICE TOOL
TO FIG. 3A
150
FARM PC

FIG. 3B

FIG. 4

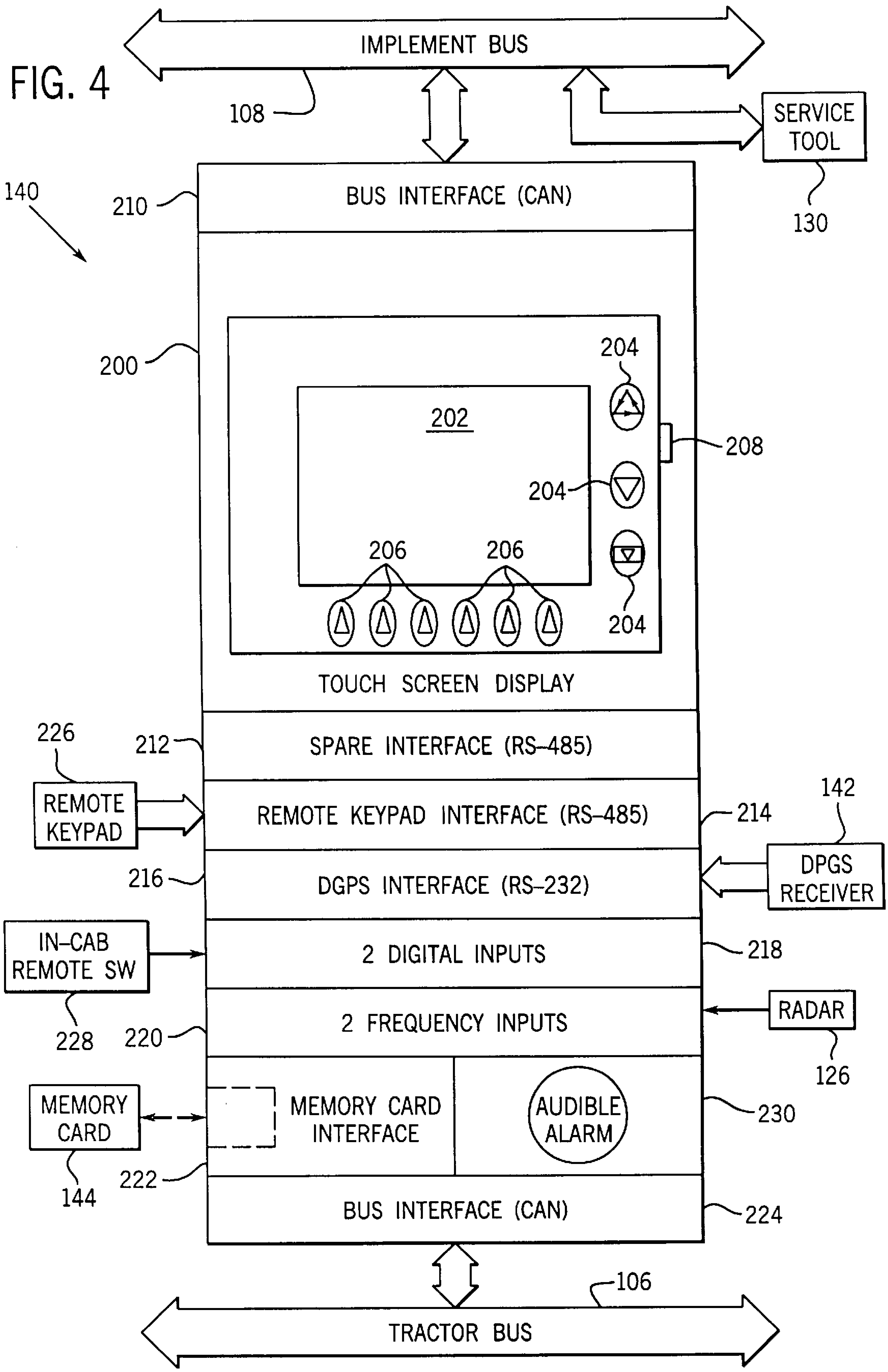
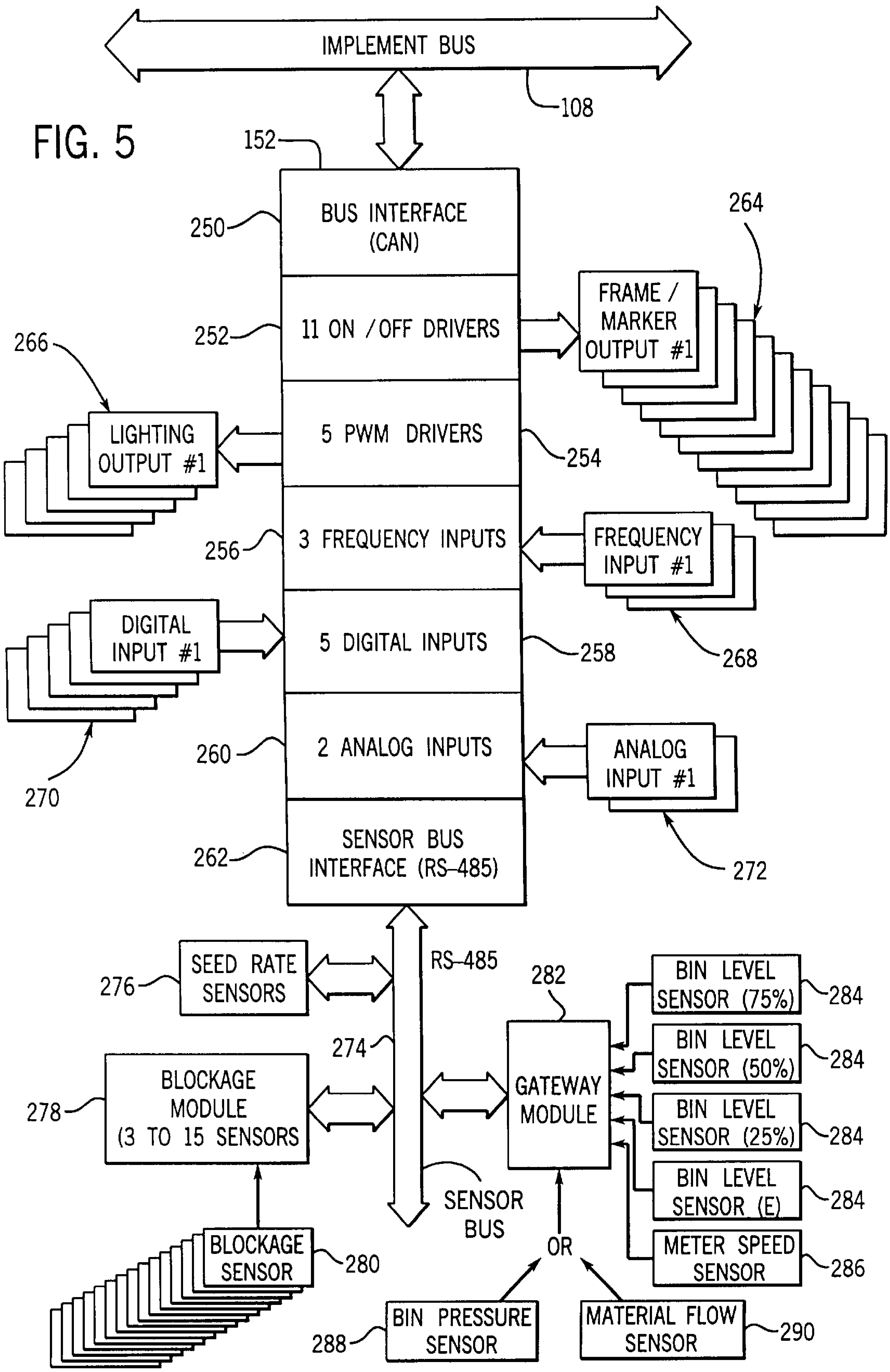

IMPLEMENT BUS
108
SERVICE TOOL
130
140
210
BUS INTERFACE (CAN)
200
204
202
208
204
206
206
204
TOUCH SCREEN DISPLAY
226
212
SPARE INTERFACE (RS-485)
REMOTE KEYPAD
REMOTE KEYPAD INTERFACE (RS-485)
214
142
216
DGPS INTERFACE (RS-232)
DPGS RECEIVER
IN-CAB REMOTE SW
2 DIGITAL INPUTS
218
228
220
2 FREQUENCY INPUTS
RADAR
126
MEMORY CARD
MEMORY CARD INTERFACE
AUDIBLE ALARM
230
144
222
BUS INTERFACE (CAN)
224
106
TRACTOR BUS

FIG. 5


IMPLEMENT BUS
108
152
BUS INTERFACE (CAN)
250
11 ON /OFF DRIVERS
252
5 PWM DRIVERS
254
3 FREQUENCY INPUTS
256
5 DIGITAL INPUTS
258
2 ANALOG INPUTS
260
SENSOR BUS INTERFACE (RS-485)
262
264
FRAME / MARKER OUTPUT #1
266
LIGHTING OUTPUT #1
FREQUENCY INPUT #1
268
DIGITAL INPUT #1
270
ANALOG INPUT #1
272
RS-485
SEED RATE SENSORS
276
274
BLOCKAGE MODULE (3 TO 15 SENSORS
278
BLOCKAGE SENSOR
280
SENSOR BUS
282
GATEWAY MODULE
BIN LEVEL SENSOR (75%)
284
BIN LEVEL SENSOR (50%)
284
BIN LEVEL SENSOR (25%)
284
BIN LEVEL SENSOR (E)
284
METER SPEED SENSOR
286
OR
BIN PRESSURE SENSOR
288
MATERIAL FLOW SENSOR
290

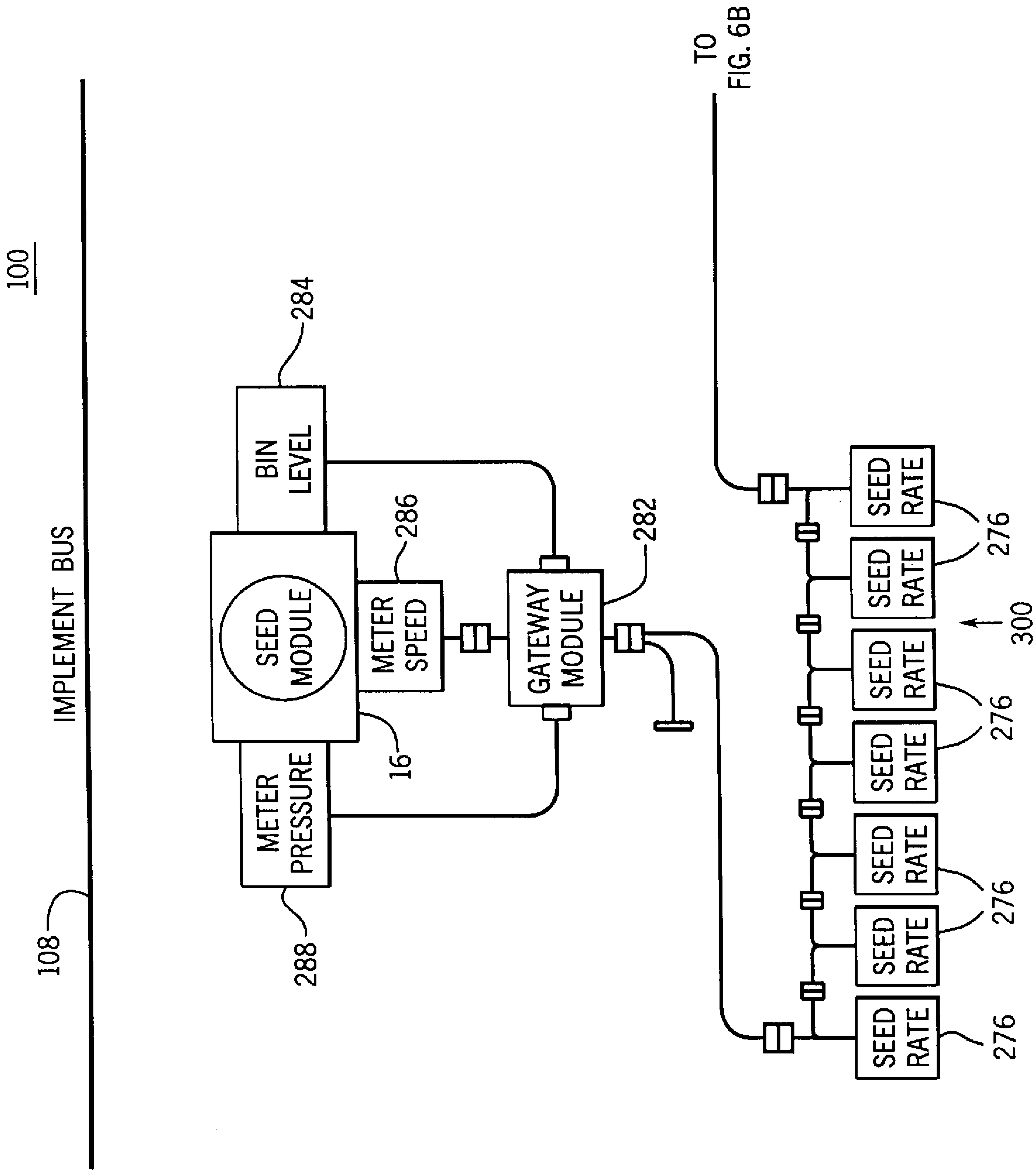

100
IMPLEMENT BUS
108
BIN LEVEL
284
SEED MODULE
METER SPEED
286
METER PRESSURE
288
16
GATEWAY MODULE
282
TO FIG. 6B
SEED RATE
276
300

FIG. 6A

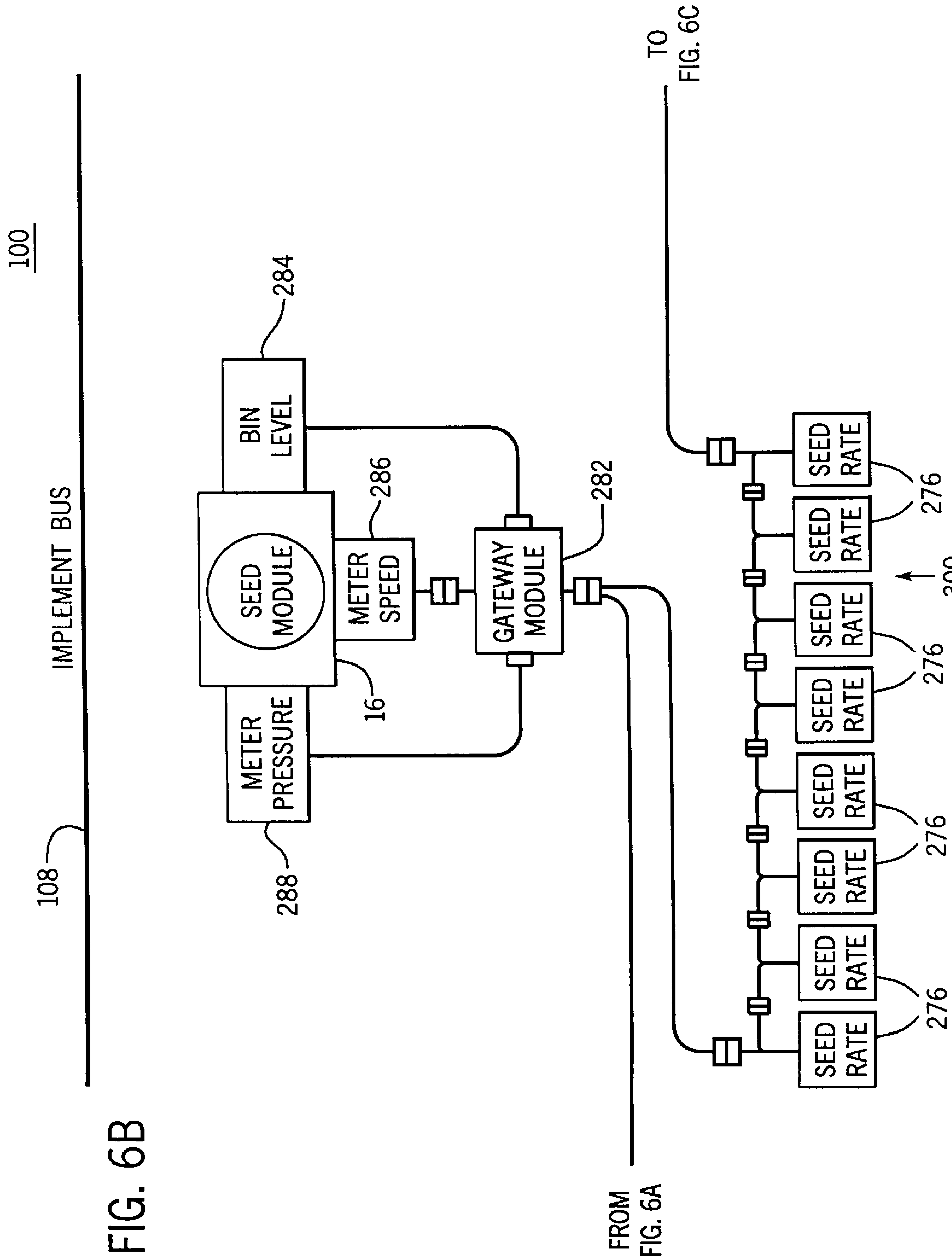

100
IMPLEMENT BUS
108
BIN LEVEL
284
SEED MODULE
METER SPEED
286
METER PRESSURE
288
16
GATEWAY MODULE
282
TO FIG. 6C
FROM FIG. 6A
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
276
276
276
276
300

FIG. 6B

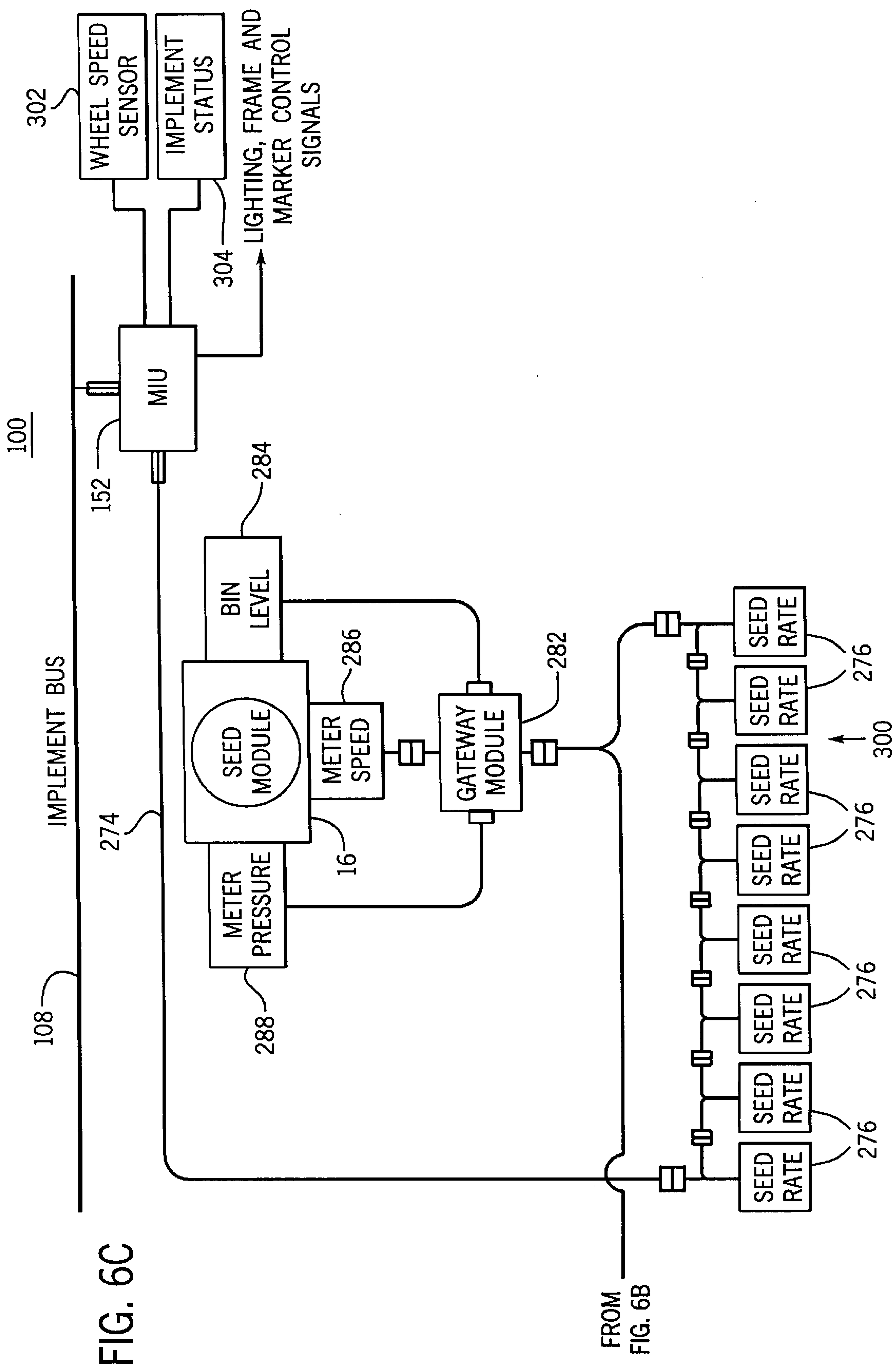

100
IMPLEMENT BUS
108
MIU
152
302
WHEEL SPEED SENSOR
IMPLEMENT STATUS
304
LIGHTING, FRAME AND MARKER CONTROL SIGNALS
274
BIN LEVEL
284
SEED MODULE
16
METER SPEED
286
METER PRESSURE
288
GATEWAY MODULE
282
SEED RATE
276
300
FROM FIG. 6B

FIG. 6C

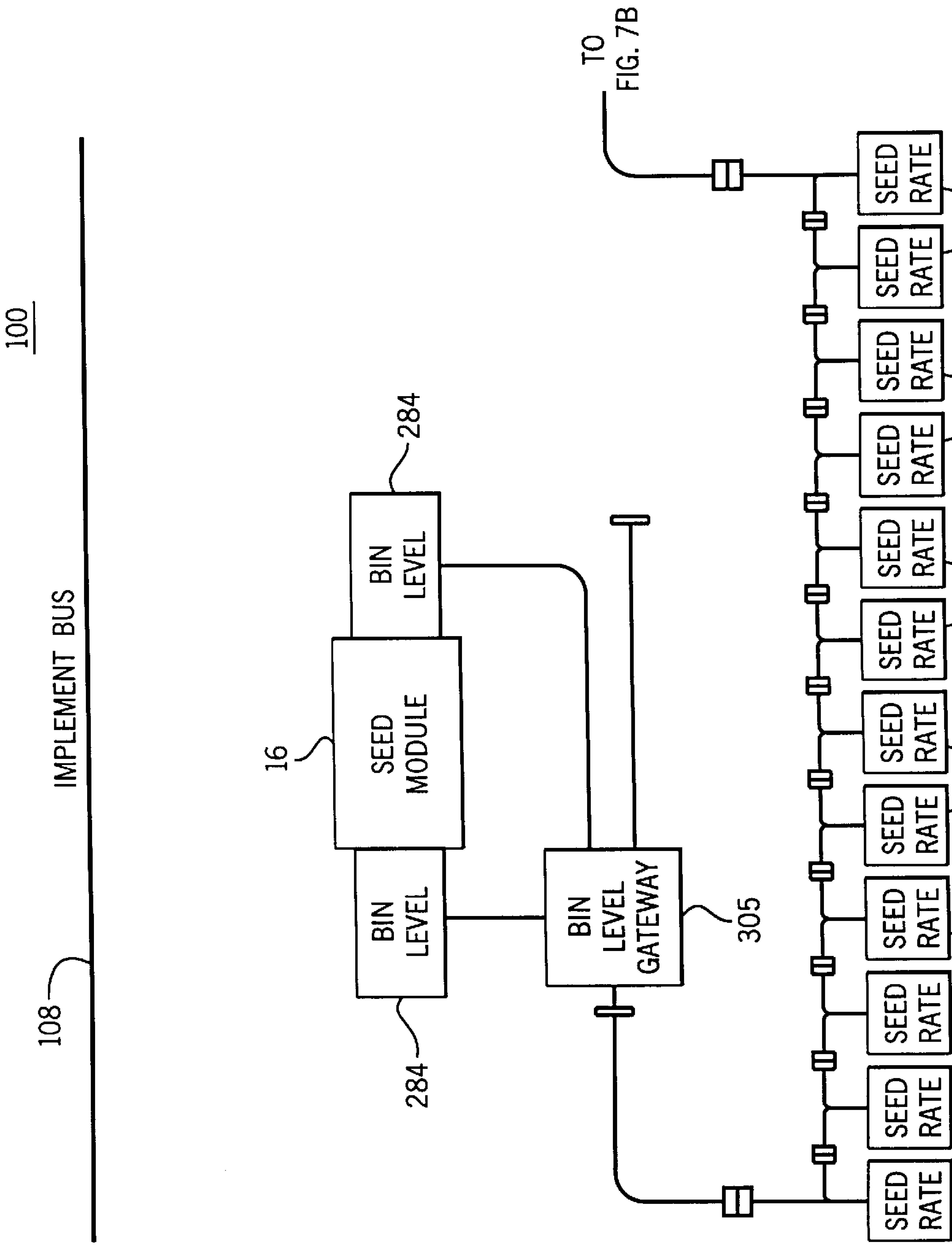

TO
FIG. 7B
100
IMPLEMENT BUS
108
BIN
LEVEL
284
SEED
MODULE
16
BIN
LEVEL
284
BIN
LEVEL
GATEWAY
305
SEED
RATE
276
300

FIG. 7A

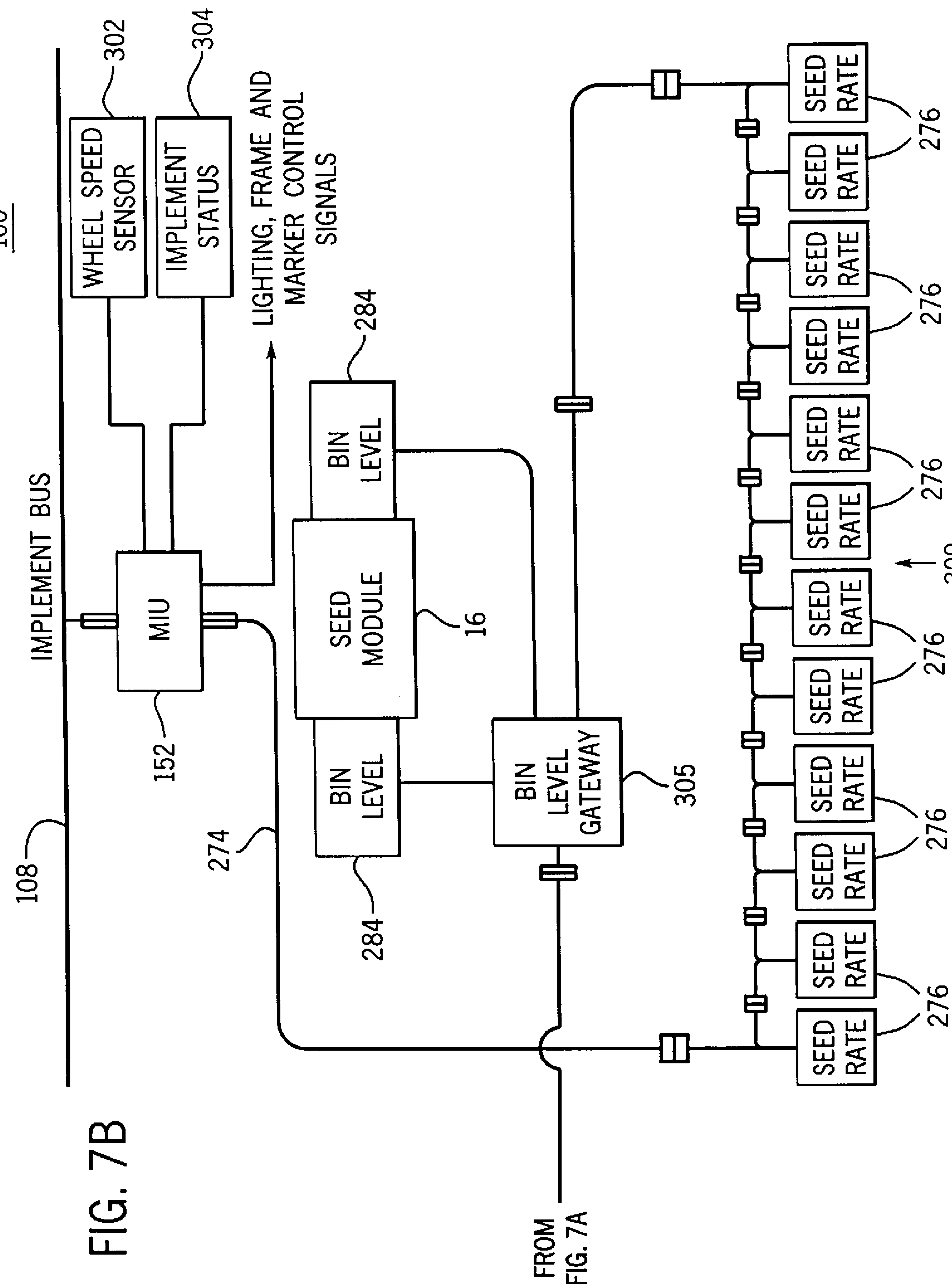

100
IMPLEMENT BUS
108
WHEEL SPEED SENSOR
302
IMPLEMENT STATUS
304
LIGHTING, FRAME AND MARKER CONTROL SIGNALS
MIU
152
SEED MODULE
16
BIN LEVEL
284
BIN LEVEL
284
BIN LEVEL GATEWAY
305
274
SEED RATE
276
300
FROM FIG. 7A

FIG. 7B

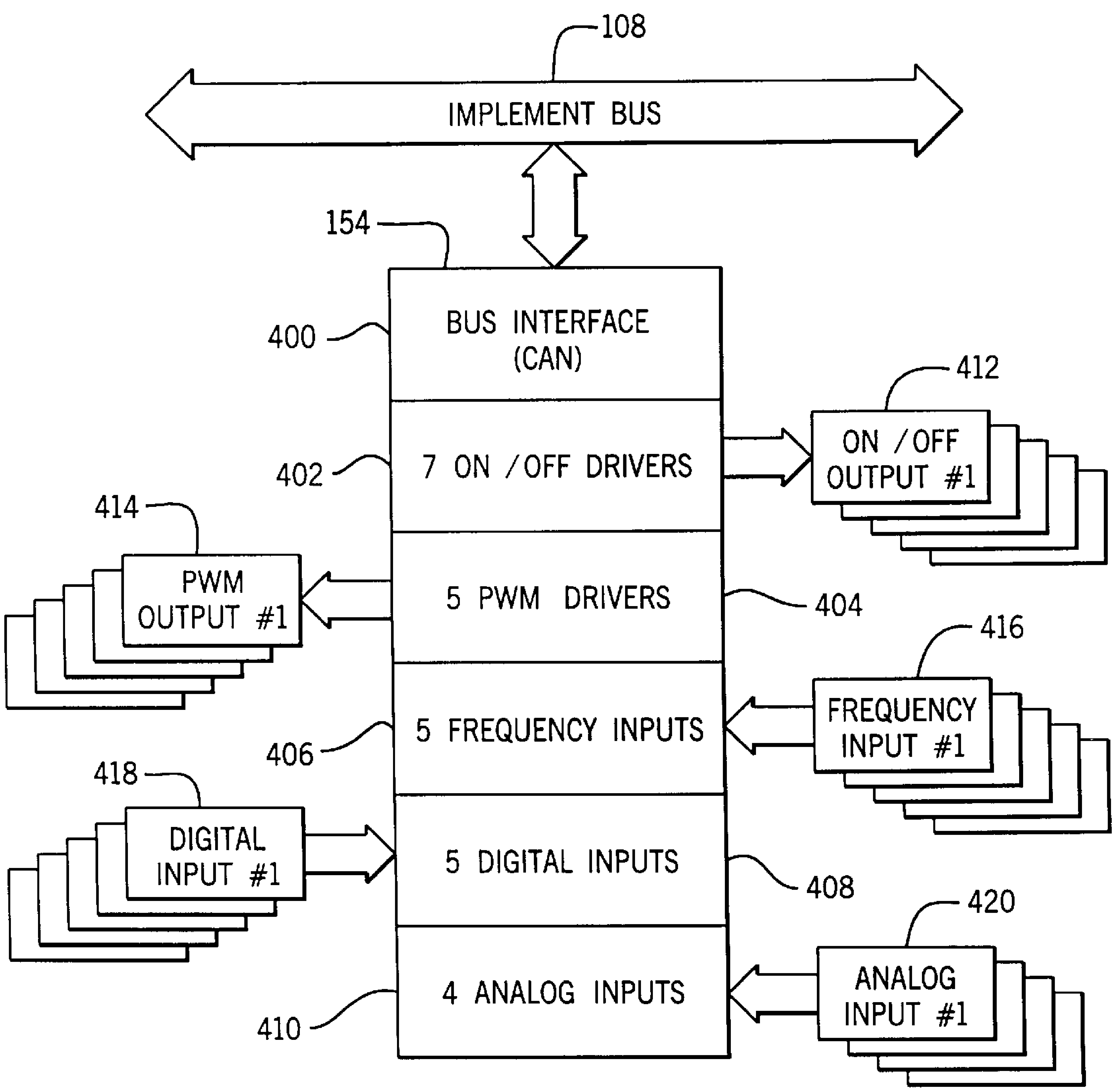

108
IMPLEMENT BUS
154
400
BUS INTERFACE (CAN)
402
7 ON /OFF DRIVERS
412
ON /OFF OUTPUT #1
414
PWM OUTPUT #1
5 PWM DRIVERS
404
416
FREQUENCY INPUT #1
406
5 FREQUENCY INPUTS
418
DIGITAL INPUT #1
5 DIGITAL INPUTS
408
420
ANALOG INPUT #1
410
4 ANALOG INPUTS

FIG. 8

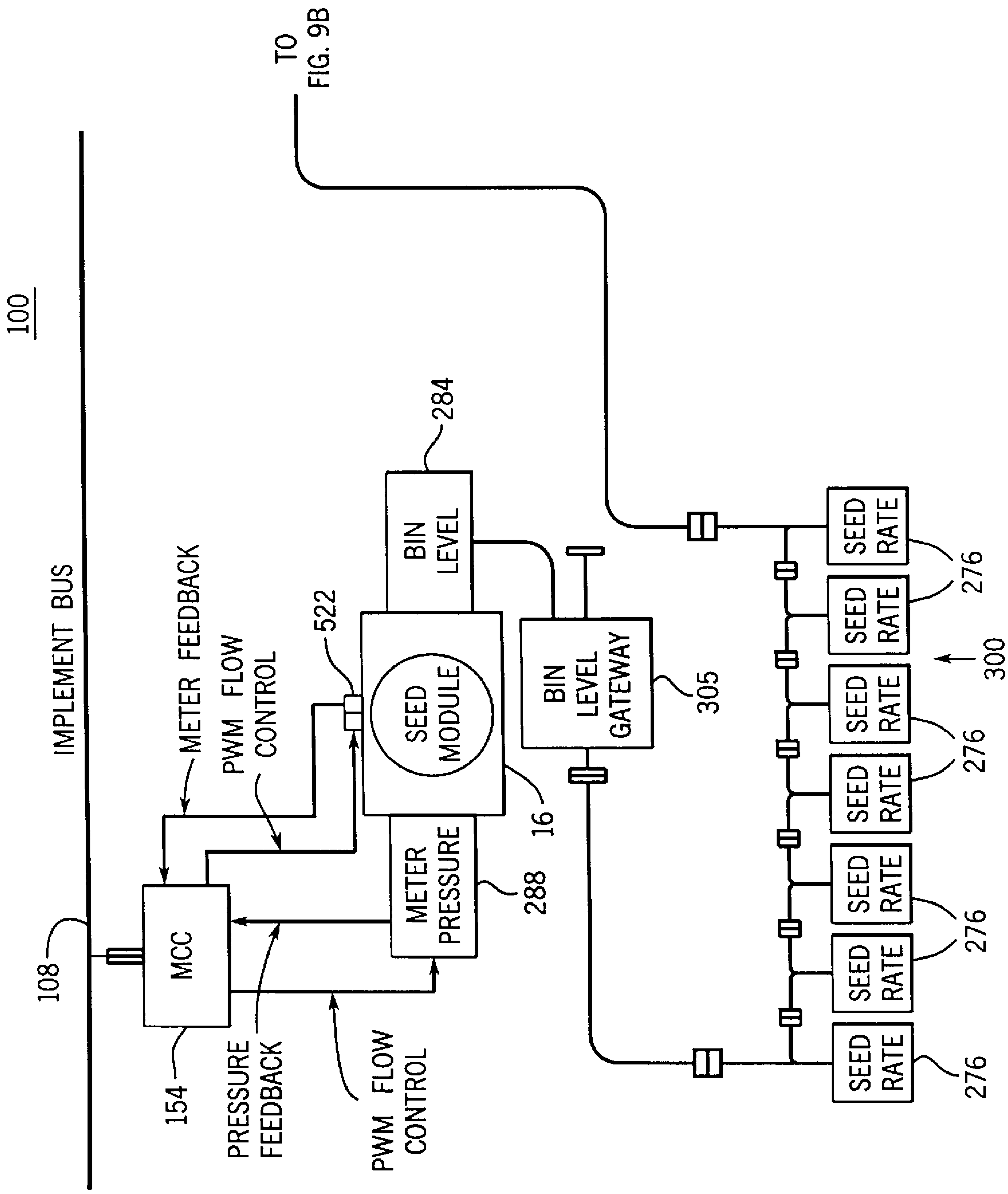

100
IMPLEMENT BUS
108
MCC
154
METER FEEDBACK
PWM FLOW CONTROL
PRESSURE FEEDBACK
PWM FLOW CONTROL
522
SEED MODULE
16
METER PRESSURE
288
BIN LEVEL
284
BIN LEVEL GATEWAY
305
TO FIG. 9B
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
276
276
276
276
276
300

FIG. 9A

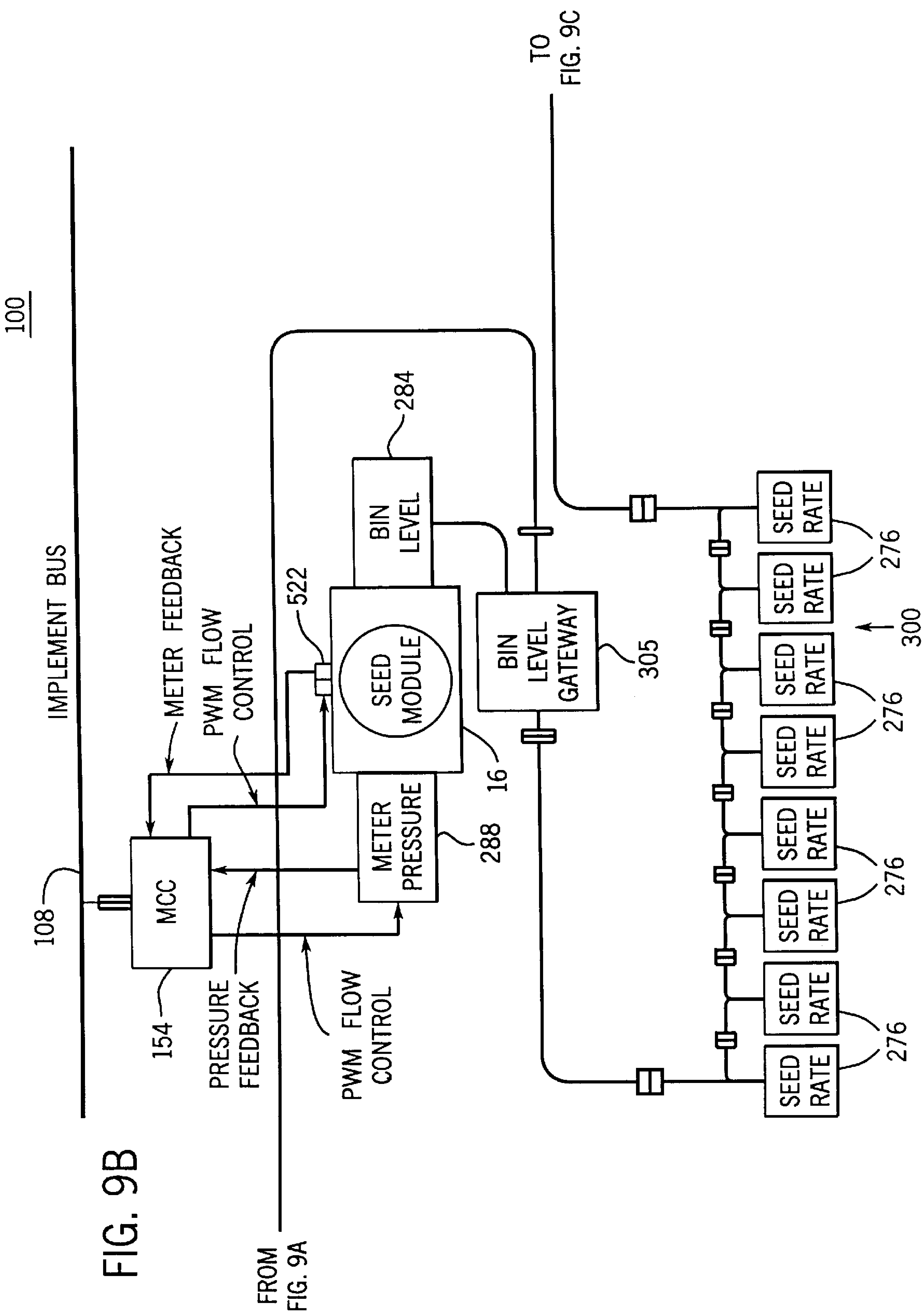

100
IMPLEMENT BUS
108
MCC
154
METER FEEDBACK
PWM FLOW CONTROL
PRESSURE FEEDBACK
PWM FLOW CONTROL
522
SEED MODULE
16
METER PRESSURE
288
BIN LEVEL
284
BIN LEVEL GATEWAY
305
TO FIG. 9C
FROM FIG. 9A
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
SEED RATE
276
276
276
276
300

FIG. 9B

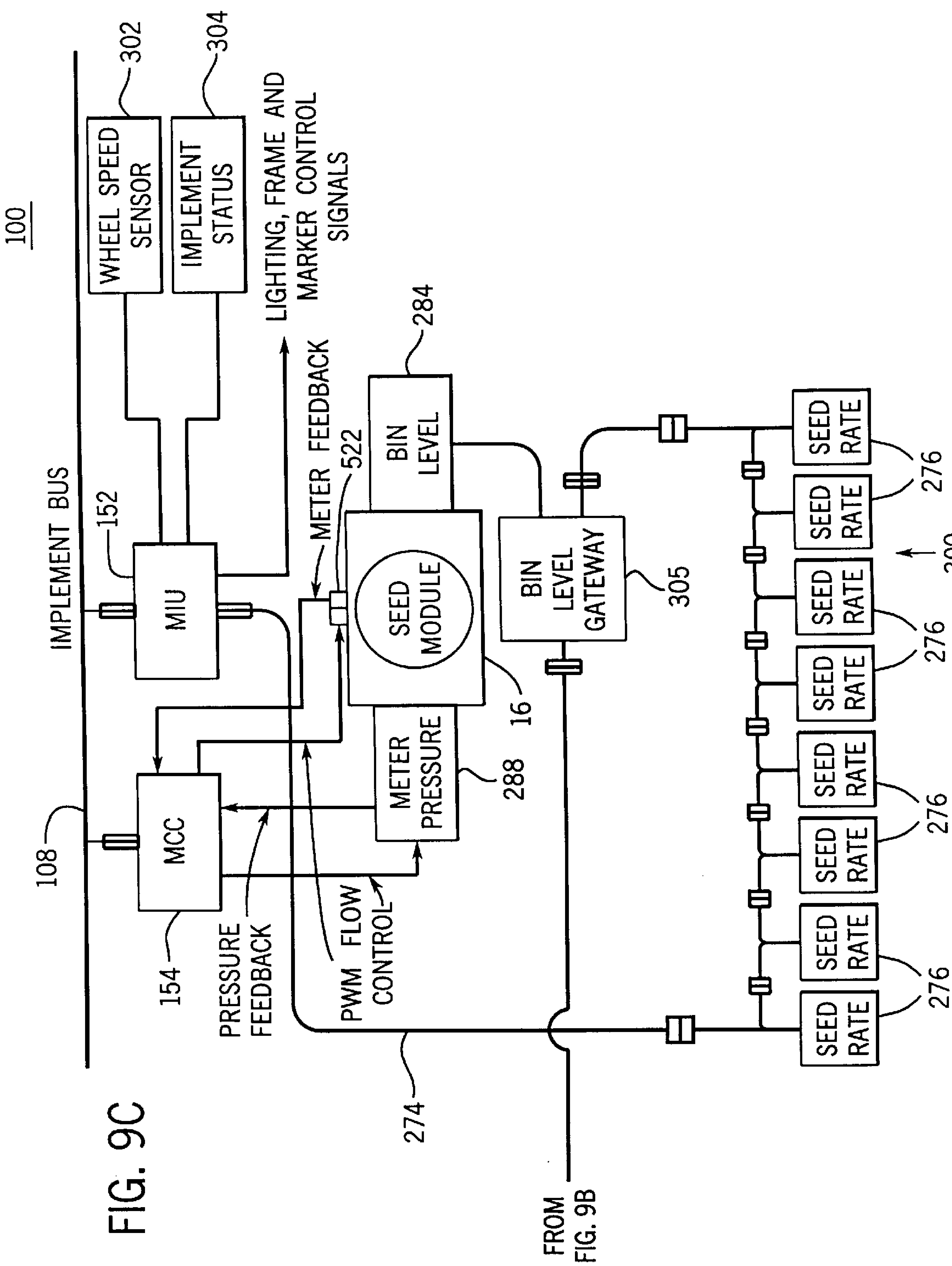
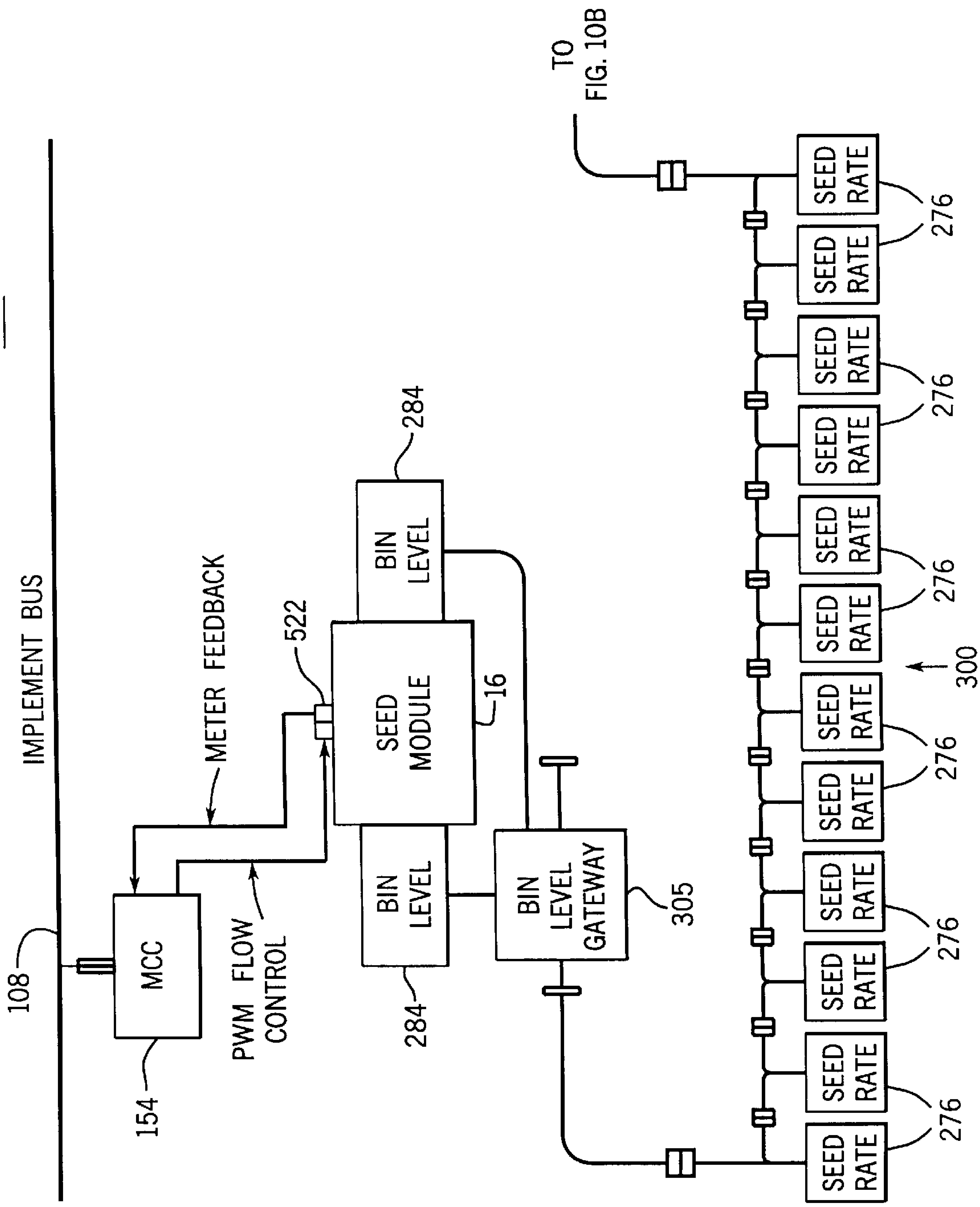

100
IMPLEMENT BUS
108
WHEEL SPEED SENSOR
302
IMPLEMENT STATUS
304
LIGHTING, FRAME AND MARKER CONTROL SIGNALS
MIU
152
MCC
154
METER FEEDBACK
522
BIN LEVEL
284
SEED MODULE
16
METER PRESSURE
288
PRESSURE FEEDBACK
PWM FLOW CONTROL
BIN LEVEL GATEWAY
305
SEED RATE
276
300
274
FROM FIG. 9B

FIG. 9C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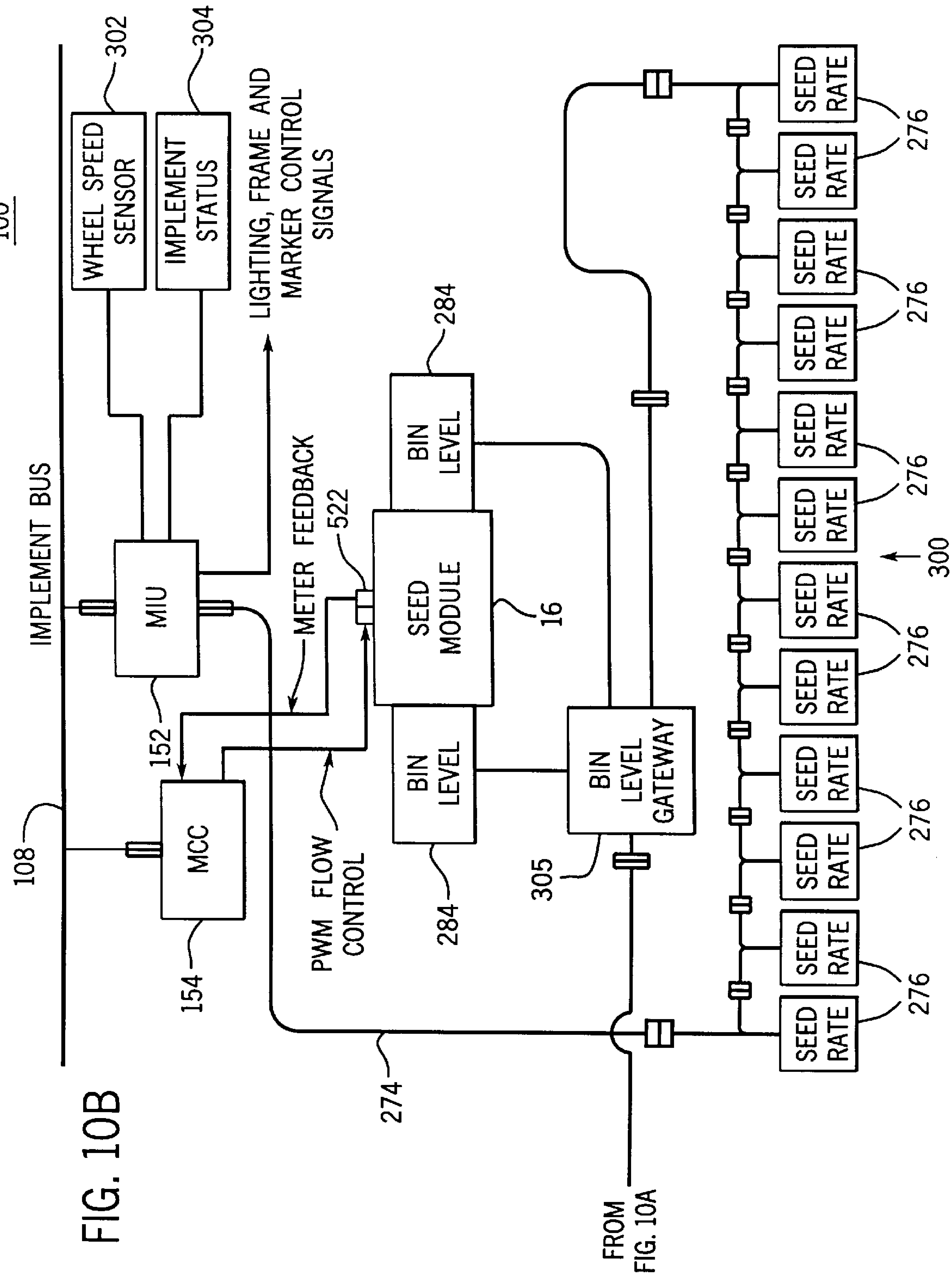
IMPLEMENT BUS
108
MCC
154
METER FEEDBACK
PWM FLOW CONTROL
522
SEED MODULE
16
BIN LEVEL
284
BIN LEVEL
284
BIN LEVEL GATEWAY
305
TO FIG. 10B
SEED RATE
276
300

FIG. 10A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IMPLEMENT BUS
108
WHEEL SPEED SENSOR
302
IMPLEMENT STATUS
304
LIGHTING, FRAME AND MARKER CONTROL SIGNALS
MIU
152
MCC
154
METER FEEDBACK
522
PWM FLOW CONTROL
SEED MODULE
16
BIN LEVEL
284
BIN LEVEL GATEWAY
305
274
SEED RATE
276
300
FROM FIG. 10A

FIG. 10B

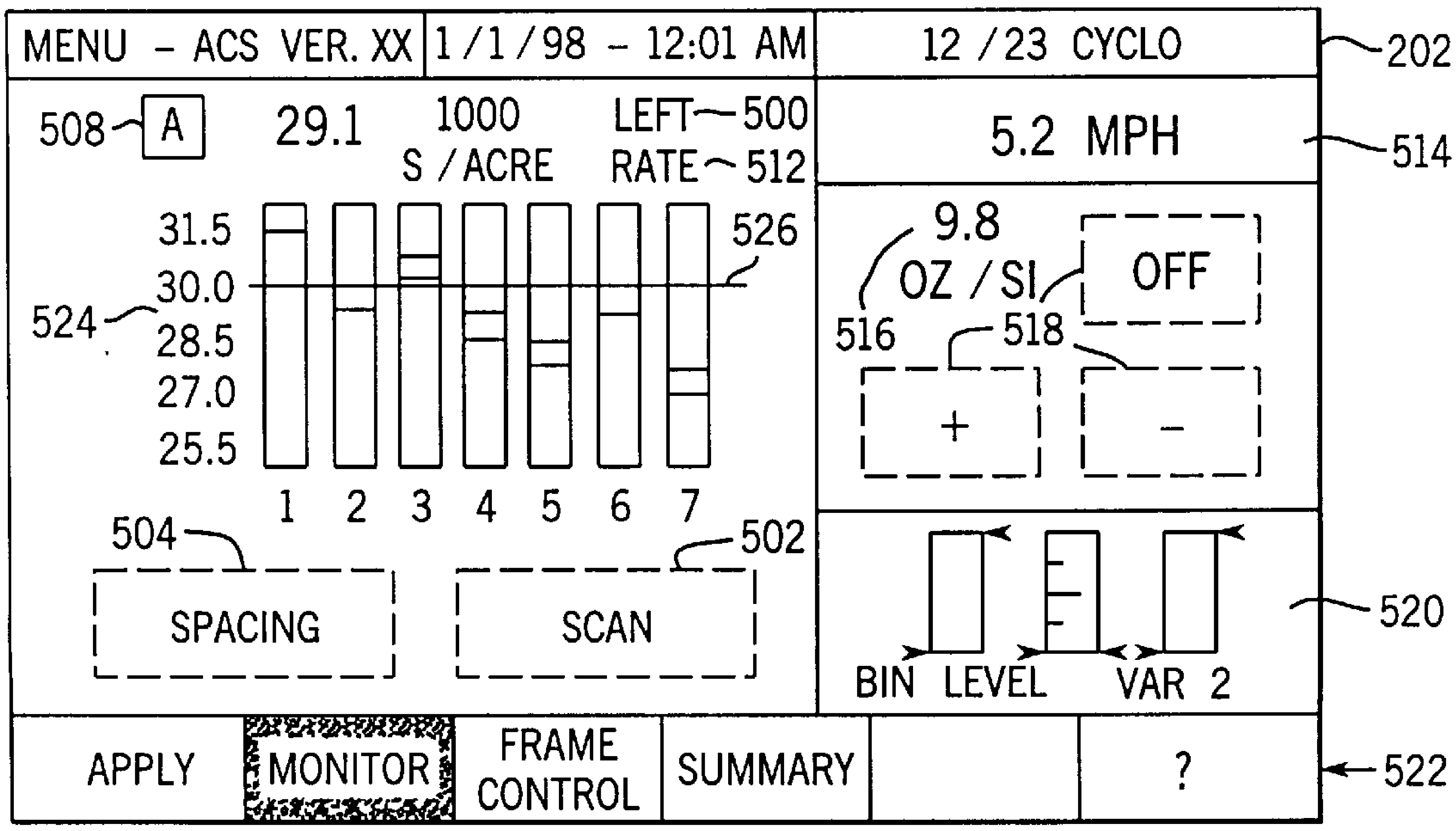

FIG. 11A

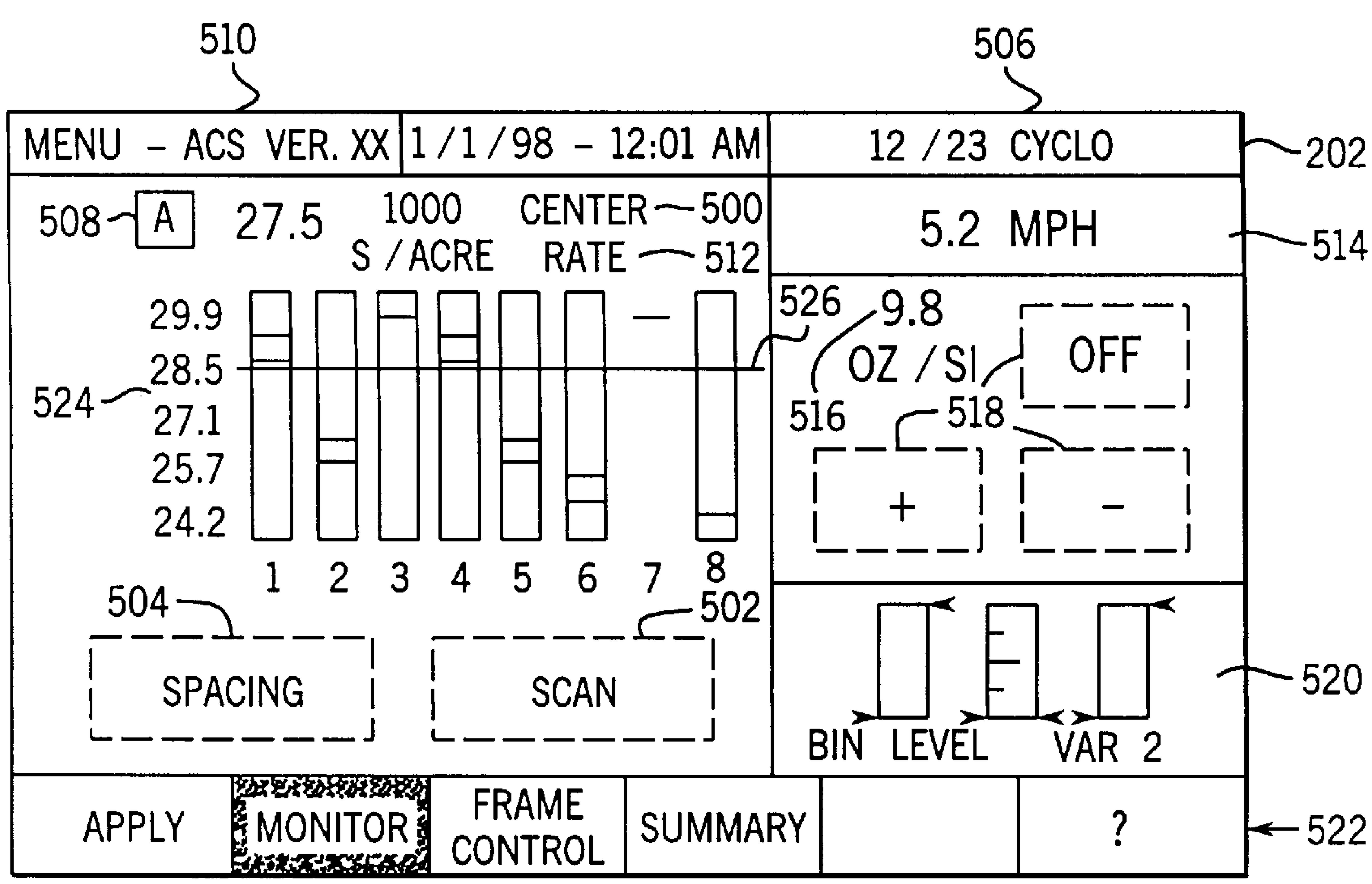

FIG. 11B

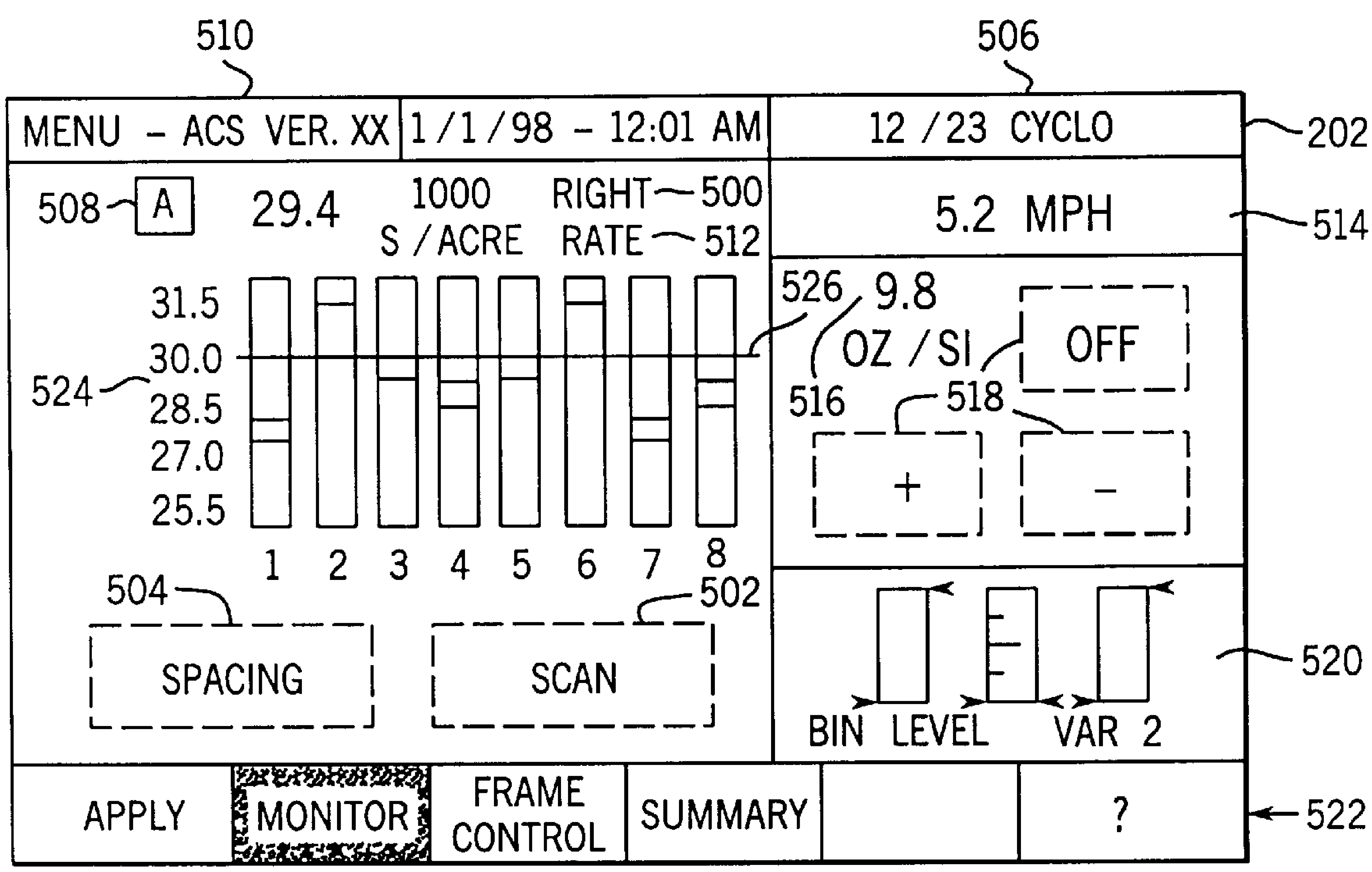
510
506
MENU - ACS VER. XX
1/1/98 - 12:01 AM
12 /23 CYCLO
202
508
A
29.4
1000
S /ACRE
RIGHT
500
RATE
512
5.2 MPH
514
31.5
30.0
28.5
27.0
25.5
524
1 2 3 4 5 6 7 8
526
9.8
OZ / SI
516
518
OFF
+
-
504
502
SPACING
SCAN
BIN LEVEL
VAR 2
520
APPLY
MONITOR
FRAME CONTROL
SUMMARY
?
522

FIG. 11C

SEED PLANTING RATE MAINTENANCE CONTROL WITH RATE DISPLAY

FIELD OF THE INVENTION

The invention generally relates to controlling the planting rate of a seed meter of an agricultural planter. In particular, the invention relates to maintaining the planting rate of the seed meter by displaying the actual seed delivery rate and adjusting an operating parameter of the planter until the displayed delivery rate comes into correspondence with a target seed delivery rate.

BACKGROUND OF THE INVENTION

Planting implements such as planters and drills are used for planting seeds in agricultural fields. Planters and drills include a frame having one or more sections. Each section supports multiple row units configured to apply seeds to a field as the implement is pulled across the field by an agricultural vehicle (e.g., a wheeled or tracked tractor). The seeds are stored in a seed bin mounted on or pulled behind the implement. Planting implements often include systems for applying granular or liquid fertilizer, insecticide or herbicide to the field.

Planters include seed meters configured to dispense or meter individual seeds to row units for application to the soil. In contrast, drills use fluted rolls to meter a mass or volume of seed. The metering and placement accuracy is typically higher for planters than drills. Seeds of crop (e.g., corn) requiring relatively accurate metering and placement for efficient growth are typically planted using planters, and seeds of crop which grow efficiently in more varied environments (e.g., oats; wheat) are planted by less accurate and expensive drills.

Many types of planters and drills are made by Case Corp., the assignee of this invention. For example, the 955 Series EARLY RISER CYCLO AIR® Planters have central-fill seed bins for storing seed, pressurized air metering systems including cyclo seed meters for metering seed, and air distribution systems for delivering metered seed to row units. Planters in this series plant different numbers of rows at different row widths. For example, a 12/23 Solid Row Crop (SRC) Cyclo Planter plants 23 narrow rows or 12 wide rows when every other row unit is locked up. Drills made by Case Corp. include the 5300, 5400, 5500, 7100 and 7200 drills which include different numbers of openers, opener spacings and seeding widths. For example, a 5500 Soybean Special Grain Drill includes 24 openers, 5 inch spacings and a 30 foot width.

Planting implements such as those described above may be equipped with variable-rate controllers permitting the operator to plant seed at target seed planting rates. Such implements may further be equipped with monitors, whether integral with or separate from the controllers, for displaying theoretical or estimated planting rates. An example of such a controller is available on the 955 Series Planters discussed above, and examples of such monitors are the Seed Flow II and Early Riser monitors sold by Case Corp. The seed planting rates are estimated because the above-described controllers and monitors do not include mechanisms or systems for counting the seeds actually planted. Rather, the rates are estimated based upon known and monitored parameters such as the meter constant (i.e., metered seeds per meter drum revolution), meter rotation speed, row width and distance traveled.

Depending on the condition and adjustments of the planting implement, estimated seed planting rates may deviate substantially from actual seed planting rates. For example, operator adjustments to 955 Series Planters which may cause errors between estimated and actual seed planting rates include: the pressure setting of the cyclo metering and distribution systems; the setting of a seed cutoff brush which removes seed from seed pockets in the drum; the height of a seed chute extension affecting the level of seed in the drum; and the height of a leveling bar ensuring the uniform distribution of seed across the bottom of the seed drum on hilly terrain. For drills, operator adjustments include the setting of a mechanical gate at the seed meter. The gate is a sliding panel that regulates the size of an opening at the base of the seed bin, and the gate setting selects the seed meter exposure (i.e., the amount of the meter in contact with the seed).

Planting implements have been adjusted based on the results of a calibration procedure wherein the seed meter is cranked a predetermined number of rotations while the dispensed seed is collected in a bag or container. The contents of the bag are manually weighed or counted to determine the amount of seed dispensed, and the planting implement is adjusted based upon the dispensed amount. The procedure is repeated until the correct adjustments are made. The need to repeat the calibration procedure multiple times is both time consuming and frustrating.

Accordingly, it would be desirable to provide a system for maintaining the planting rate of a planting implement based upon an actual or sensed seed count. It would be desirable to display maintenance seed planting rates in a format easily used to determine the difference between the actual seed planting rate and a target rate. It would also be desirable to allow an operator to make on-the-fly adjustments of seed planting parameters (e.g., air pressure, brush spacing, etc.) while displaying the effects of such adjustments to the operator in real-time. The display would indicate when the actual seed planting rate comes into general correspondence with a target seed planting rate. Such an improved maintenance system would eliminate the need to manually collect and then count the seed delivered during a predetermined interval, and would eliminate the need to repeatedly calibrate and re-adjust the implement until the actual seed planting rate comes close to the target rate. It would further be desirable to allow maintenance adjustments to be made while the planter remains still or to be made independent of speed.

SUMMARY OF THE INVENTION

One embodiment of the invention provides a seed planting system for planting seed in soil at desired rates. The system includes a tractor with an operator station (e.g., a cab), a seed planter including a seed channel having an exit through which a number of seeds move toward the soil, an electronic seed sensor attached to the planter to generate a seed signal representing the number of seeds, an electronic display supported at the operator station, and an operator-activated control at the operator station. A digital processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, and applies a display signal to the display to generate a first image on the display representative of the actual seed delivery rate. The processing circuit also modifies a parameter affecting the seed delivery rate in response to activation of the operator-activated control.

Another embodiment of the invention provides a seed planting monitoring system. The system is used with a planting arrangement having an operator station, a seed delivery system having a target seed delivery rate controlled by a control signal, and at least one seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted. The system includes an electronic seed sensor attached to the seed delivery system which generates a seed signal representative of the number of seeds, an electronic display supported at the operator station, and an operator interface. A digital processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter affecting the seed delivery rate in response to activation of the operator interface.

A further embodiment of the invention provides a method for monitoring the operation of a seed planter from the cab of a tractor, wherein the seed planter is of the type including a seed delivery system having a target seed delivery rate controlled by a control signal, and at least one seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted. The method includes generating a seed signal representative of the number of seeds, applying the control signal to the seed delivery system to control the target seed delivery rate, and monitoring the seed signal to determine an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored. The method also includes generating a display signal representing the actual seed delivery rate, and applying the display signal to an electronic display located in the cab to generate an image on the display representative of the actual seed delivery rate.

Another embodiment of the invention provides a metering system for selectively applying material to the soil of a field. The system includes a tractor having a cab, and a material meter towed by the tractor and including at least one channel having an exit through which an amount of material moves toward the soil. An electronic sensor supported relative to the meter generates a material signal representative of the amount of material, and an electronic display supported within the cab. A digital processing circuit monitors the material signal, determines an actual material delivery rate based upon the amount of material and a time period during which the material signal is monitored, and applies a display signal to the display to generate an image representing the actual material delivery rate.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will become more fully understood from the following detailed description, taken in conjunction with the accompanying drawings, wherein like reference numerals refer to like parts, in which:

FIG. **1** is a top view of a planting implement such as a 12/23 SRC Cyclo Planter;

FIG. **2**A is a schematic diagram illustrating a section of the planting implement of FIG. **1** which includes eight row units and a cyclo seed metering device configured to meter seed and deliver the metered seed to the row units;

FIG. **2**B is a schematic representation of an assembly for adjusting the orientation of the seed brush in the planter drum shown in FIG. **2**A;

FIGS. **3**A–**3**B depict a block diagram of the control system for an agricultural vehicle and the planting implement of FIG. **1** which includes vehicle and implement data busses;

FIG. **4** is a block diagram of the cab display unit (CDU) of FIGS. **3**A–**3**B, and the interfaces between the CDU and other components of the control system;

FIG. **5** is a block diagram of the monitor interface unit (MIU) of FIGS. **3**A–**3**B, and the interfaces between the MIU and other components of the control system;

FIGS. **6**A–**6**C depict a block diagram of a control system for the planting implement of FIG. **1** including an MIU for monitoring seed rate sensors coupled to the row units;

FIGS. **7**A–**7**B depict a block diagram of a control system useable with a drill planter which includes an MIU for monitoring seed rate sensors coupled to the row units;

FIG. **8** is a block diagram of one multi-channel controller (MCC) of FIGS. **3**A–**3**B, and the interfaces between the MCC and other components of the control system;

FIGS. **9**A–**9**C depict a block diagram of a control system for the planting implement of FIG. **1** which further includes local MCCs to control the planting rates of each section;

FIGS. **10**A–**10**B depict a block diagram of a control system for the drill as in FIGS. **7**A–**7**B which further includes local MCCs to control the seed planting rates of each section; and

FIGS. **11**A–**11**C show a sequence of CDU display screens allowing the operator to monitor the performance of each section and row unit of the implement, and to determine whether each section and row unit is planting seed at an actual rate consistent with a desired seed planting rate.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. **1**, a planting implement **10** (e.g., 12/23 SRC Cyclo Planter) includes a support structure such as a frame **12**, row units **14** mounted beneath frame **12**, and seed modules **16** supported on frame **12**. Frame **12** includes a middle section **18**, wing sections **20** on either side of section **18**, and a drawbar **22** extending forward from section **18**. Wing sections **20** rotate inwardly to drawbar **22** to decrease implement width during transport. A hitch having an eye **24** to drawbar **22** connect to an agricultural vehicle such as a tractor (**102** in FIGS. **3**A–**3**B). Twenty-three row units **14** are configured to plant seed in 23 rows of a field with all row units **14** down, or in 12 rows with every other row unit **14** locked up. Each module **16** meters seeds for row units **14** of one section. For example, the sections in FIG. **1** include 7, 8 and 8 row units **14**, respectively, from left to right. Metered seeds are delivered through seed tubes (**30** in FIG. **2**A) from modules **16** to row units **14**. Bins **25** storing other products (e.g., fertilizer, insecticide or herbicide), and metering devices therefore, are also supported by frame **12**. Markers attached to either side **26** of frame **12** mark the centerline of the next pass through a field.

Referring to FIG. **2**A, one section of implement **10** includes eight row units **14**, a seed module **16** mounted on frame **12**, and seed tubes **30** for moving seed from module **16** to row units **14**. Seed module **16** includes a cyclo seed meter **32** for metering or singulating seed and to deliver the metered seed to row units **14**. Cyclo seed meter **32** includes a perforated drum **34** secured by a shaft **36** to a hydraulic motor **38**. The holes in drum **34** are arranged in circumferentially-spaced rows (e.g., 8 rows for an 8-row planter), with each row having a plurality of holes with diameters smaller than the seed being planted. The drum arrangement depends on the type of seed, and a line of interchangeable drums is made by Case Corp. A seed bin **40** stores the seed being planted. A hydraulic blower includes a hydraulic motor **42** and a fan **44** to provide pressurized air to bin **40** and to drum **34**. Seeds move from bin **40** to drum **34** via a seed chute (not shown) with the aid of higher air pressure in bin **40** than drum **34**.

During operation, blower **42–44** pressurizes drum **34** to create an air pressure differential above atmospheric, but lower than the air pressure in bin **40**. As motor **38** rotates drum **34**, the differential causes each hole to pick up one seed at the bottom of drum **34**, and to retain the picked-up seeds against their respective holes **41** as drum **34** rotates. To increase the probability that one, and only one, seed is in a hole, a brush **35** sweeps the inside of drum **34**. After further rotation moves the retained seeds above a manifold defined by openings of seed tubes **30** adjacent to drum **34**, holes **41** are plugged by release wheels external to drum **34** to eliminate the forces which retain the seeds and cause the seeds to drop into tubes **30**. The seeds are pushed by a cushion of pressurized air through seed tubes **30** to row units **14** to be planted. A press wheel **46** compresses the soil over the planted seed.

Referring to FIG. 2B, the pressure between brush **35** and drum **34** is adjustable. In particular, brush **35** is positioned against the interior of drum **34** with two positioners **37** attached at the inside of drum **34** to bin **40** by a support member **39**. Positioners **37** are controlled by a multi-channel **154** (FIGS. 3A–3B), and may take the form of motor (D.C., stepping, etc.) driven screw positioners, electronically controlled, solenoid-operated hydraulic cylinders, etc. In operation, positioners **37** can adjust the pressure of brush **35** along its length by independently controlling the positioners. Alternatively, where control of the brush pressure along its length is not important, a single positioner **37** and appropriate brush support structure can be used.

Ideally, the seed application rates depend upon the rotation rate of drum **34**. A variable application rate is obtained by controlling the rotation rate of drum **34** as a function of the ground speed (e.g., measured using implement wheel speed sensor **302** in FIGS. 6A–6C) and a commanded application rate. A valve assembly supplies pressurized hydraulic fluid to motor **38** to rotate shaft **36** at a variable rate in response to rate control signals applied to the valve assembly.

As discussed, seed application rates depend primarily on the rotational speed (rate) of drum **34**. However, seed application rates also depend upon the air pressure in bin **40** and drum **34**, and the pressure of brush **35** against the inside surface of drum **34**. Accordingly, as discussed in further detail below, system **100** can be operated in a maintenance mode wherein drum **34** is rotated at a speed which should provide a desired seed flow rate (e.g., 40 rows of eight holes around the circumference of drum **34** should provide a seed rate of 40 seeds per revolution per seed tube **30**). If the operator determines from the seed rate displayed on display **202** that the desired seed rate is not obtained in the maintenance mode then a parameter of the planter (e.g., drum air pressure or brush pressure) can be adjusted by the system operator.

Referring to FIGS. 3A–3B, a control system **100** controls planting implement **10** (e.g., a planter or drill) as it is pulled across a field by vehicle **102**. Control system **100** includes electronic control units (ECUs) in communication with each other across a vehicle data bus **104**. Vehicle data bus **104** includes a tractor bus segment **106** to pass data throughout vehicle **102**, and an implement bus segment **108** to communicate between vehicle **102** and implement **10**. Bidirectional data passes between busses **106** and **108** via a network interconnection ECU **110** (e.g., a gateway). Bus **104** preferably conforms to the "Recommended Practice for a Serial Control and Communications Vehicle Network" (SAE J-1939) which uses Controller Area Network (CAN) protocol for low-layer communications. ECU **110** performs network functions as described in the Network Layer specification of J-1939 by acting as a repeater for forwarding messages between segments **106** and **108**, a bridge for filtering out messages not needed by the receiving segment, a message router for remapping addresses and a gateway to repackage messages for increased efficiency. Other bus formats, however, may also be used and ECU **110** may perform all or only a subset of the above-listed network functions.

Other ECUs coupled to tractor bus **106** include an armrest control unit (ARU) **112**, instrument cluster unit (ICU) **114**, auxiliary valve control unit (AUX) **116**, electronic draft control unit (EDC) **118**, transmission control unit (TCU) **120**, power take-off control unit (PTO) **122**, and engine governor control unit (GOV) **124**. ICU **114** receives signals from a true ground speed sensor **126** (e.g., a radar) mounted to the body of vehicle **102**. Ground speed sensor **126** (e.g., a radar) may also be in direct communication with a cab-mounted display unit (CDU) **140**. A service tool **130** can be coupled to busses **106** and **108** via a diagnostic connector **132** for use during diagnostics and maintenance.

The ECUs coupled to tractor bus **106** are illustrative and other control units such as a tractor performance monitor control unit or steering control unit could also be connected to bus **106**. Further, the use of gateway **110** for communications between busses **106** and **108** allows a higher level of integration in tractors equipped with a tractor data bus. However, implement bus **108** and its associated ECUs may also be used to control implements pulled by other tractors which have no tractor data bus.

Implement bus **108** includes first and second segments **134** and **136** coupled via a connector **138** at the rear of vehicle **102**. Segment **134** passes through vehicle **102** and segment **136** provides a communication pathway to implement **10**. Thus, implement bus **108** reduces wiring needs between implement **10** and vehicle **102**. Besides gateway ECU **110**, ECUs coupled to segment **134** include cab-mounted display unit (CDU) **140**. CDU **140** provides an operator interface, a serial interface (e.g., RS-232) to receive positioning signals from a DGPS receiver **142**, and an interface for a memory card **144** (e.g., a PCMCIA card). Receiver **142** receives GPS and DGPS signals from antennas **146** and **148**. Memory card **144** transfers geo-referenced map data (e.g., prescription and application rate maps defined by GIS or Global Information System databases) between control system **100** and an external computer **150**. Prescription maps include application rate commands, and application rate maps record actual (i.e., sensed) application rates.

ECUs coupled to segment **136** of implement bus **108** are mounted to frame **12** of implement **10**. These ECUs include a monitor interface unit (MIU) **152** and one or more multi-channel control units (MCCs) **154**. Each implement section typically includes one "local" MCC **154** to control product application rates. MIU **152** monitors application rates of products (e.g., seeds) to rows and other parameters (e.g., bin level, ground speed, wheel speed, meter pressure) based on signals generated by monitoring sensors **156**, implement status devices **158** and a wheel speed sensor **128** (e.g., inductance magnetic pickup sensor) coupled to the vehicle's wheels. MIU **152** also receives global commands from CDU **140** via bus **108**, generates global control signals using the global commands, and applies the global control signals to global output devices **160** to perform global implement functions (e.g., lighting, frame, marker control). MCCs **154** receive commands from CDU **140** based on signals generated by application sensors **161**, generate local control signals for local product metering devices **162**, and apply the local control signals to metering devices **162**. Further, MCCs **154** may generate control signals for a variety or type switch **164** which selects the variety or type of farming inputs applied, control signals for blower control **163** which powers blower **42**, and control signals for positioner control **167** which controls the operation of positioners **37**. MCCs **154** may also generate control signals for a section control switch **165** which selects which sections are enabled or disabled.

Referring to FIG. **4**, CDU **140** is an ECU mounted in the cab of vehicle **102**. CDU **140** includes a display unit **200** including a touch screen **202** (e.g., a TFT 10.4" color display with digital touch screen), system touch screen switches **204**, reconfigurable touch screen switches **206** and system reset switch **208**. A 1/2 VGA monochrome DMTN display with LED backlighting could also be used. CDU **140** has interfaces **210–224** for implement bus **108**, a remote keypad **226**, DGPS receiver **142**, digital inputs (e.g., an in-cab remote switch **228**), frequency inputs such as radar **126**, memory card **144** and tractor bus **106**. CDU **140** includes an audible alarm **230**. A processor (e.g., ARM LH74610 RISC processor) coupled to memory circuits (e.g., RAM, EEPROM, Flash EPROM) provides control for CDU **140**.

Control system **100** can control different planting implement applications. An operator uses touch screen **202** to navigate and perform common functions within each application. System touch screen switches **204** include a MODE switch for toggling between applications, a CALIBRATE switch for performing configuration, calibration and seed rate maintenance functions, and a UTILITY switch for performing file transfers on card **144**. Touch screen switches **206** select between items on reconfigurable menus to control the operations of control system **100**. Reset switch **208** resets control system **100**. Remote keypad **226**, mounted via a cable near the operator when CDU **140** is mounted elsewhere in the cab, duplicates touch screen switches **206**. In-cab remote switch **228** allows the operator to remotely start and stop product metering. Alarm **230** is used to alert the operator to error and alarm conditions.

Both global and local operations of implement **10** are controlled by actuations of touch screen switches **204–206**. The global functions include lighting control (e.g., turning on and off lights attached to frame **12**), frame control (e.g., raising and lowering frame **12**; folding and unfolding wings **20**) and marker control (e.g., alternately raising and lowering markers attached to both sides **26** of frame **12** to mark the centerline of the next pass), blower **42** control (i.e., air pressure in drum **34** and bin **40** control) and positioner **37** control (i.e., brush **34** pressure control). Actuations needed to control the global functions depend on the particular implement. When switch actuations relate to lighting, frame or marker control, CDU **140** generates global command signals which are communicated to MIU **152** via bus **108** for controlling global output devices **160**.

Referring again to the seed rate maintenance mode discussed above, the operator activates the mode switches **204** to enter the maintenance mode. In this mode, CDU **140** applies commands to MCC's **154** which causes drum **34** to rotate at the speed required to achieve selected seed delivery rates. (See the discussion of FIGS. **9A–9C** below for more details.) CDU **140** monitors the seed rate signals generated by MIU **152**, and displays the selected seed delivery rates and actual seed delivery rates on display **202**. Based upon a comparison of the desired and actual seed delivery rates, the operator increments or decrements the desired seed delivery rate using touch screen **202** to cause CDU **140** and MCC **154** to vary the speed of blower **42** (i.e., bin **40** and drum **34** air pressure) and/or actuate positioners **3** to vary brush **35** pressure to bring the desired and actual seed delivery rates into correspondence.

The local implement functions include variable-rate application of products to a field. Touch screen switches **204–206** are actuated to control the rates in a manual or an automatic mode. In manual mode, the actuations set, increase or decrease the desired application rates for one or more products applied by each section. In automatic mode, the actuations select between one or more prescription maps stored on card **144**. The maps include geo-referenced data representing desired application rates of one or more products at positions throughout a field. Desired rates are determined, for example, off-line using computer **150**. The selected maps are indexed using positioning signals received by DGPS receiver **142** to determine the desired application rates which are then used to generate local product rate commands transmitted to MCCs **154**.

Referring to FIG. **5**, MIU **152** is an ECU supported on frame **12** which includes interfaces **250–262** for implement bus **108**, frame/marker outputs **264** (e.g., markers **50**; wings **20**), lighting outputs **266**, frequency inputs **268**, digital inputs **270**, analog inputs **272** and sensor bus **274**. MIU **152** is connected in control system **100** as shown below. Sensor bus **274** is coupled to seed rate sensors **276**, a blockage module **278** coupled to blockage sensors **280**, and a gateway module **282**. Optical seed rate sensors **276** detect seeds passing through seed tubes to row units **14**. Module **282** receives signals from optical bin level sensors **284**, a meter speed sensor **286**, and a bin pressure **288**. Signals from bin level sensors **284** indicate when bins **40** of modules **16** are 75% full, 50% full, 25% full, and Empty. Sensor bus **274** is preferably an RS-485 network as described in U.S. Pat. No. 5,635,911, herein incorporated by reference. MIU **152** is controlled by a processor (e.g., an AN80C196CB) coupled to memory (e.g., RAM, EEPROM, Flash EPROM).

Control system **100** is a modular application control system which can be upgraded with additional controllers for expanded functionality. Initially, control system **100** includes CDU **140**, implement bus **108** and MIU **152** which provide monitoring and global control functions. In the initial system, product application rates are controlled conventionally (e.g., by driving product metering devices using gears coupled to the implement wheels). FIGS. **6A–6C** and **7A–7B** show control system **100** in embodiments which provide for monitoring and global control functions for implements. Control system **100**, however, can later be upgraded with MCCs **154** to provide variable-rate control. FIGS. **9A–9C** and **10A–10B** show upgraded control system **100** for the same implements.

Referring to FIGS. **6A–6C**, control system **100** controls a 12/23 SRC Cyclo Planter implement **10** which includes three sections **300**, each supporting multiple (e.g., 7, 8 and 8) row units **14** configured to apply seeds to a field. Seeds are metered by a seed module **16** on each section **300**. MIU **152** receives global command signals via bus **108** from CDU **140**, and transmits back monitored data. MIU **152** receives speed signals used to calculate seeding data (e.g., area seeded) from a sensor **302** coupled to the planter's wheels. MIU **152** also receives signals indicating whether implement **10** is up or down from a status sensor **304**. The application of products is disabled when implement **10** is raised, and is enabled with implement **10** down and ground speed above a predetermined value (e.g., 0.22 m/sec.).

Sensor bus **274** is connected to a seed rate sensor **276** associated with each row unit **14**. MIU **152** monitors seed application rates using signals received from seed rate sensors **276**, and sends seed rate data to CDU **140** via bus **108**. Bus **274** is also coupled to a gateway module **282** on each section **300** to monitor the status of each seed module **16** using signals received from bin level sensors **284**, meter speed sensor **286**, and bin pressure sensor **288**. MIU **152** transmits meter status to CDU **140**. Connectors separate MIU **152**, sensors **276** and gateway modules **282**.

Referring to FIGS. **7A–7B**, another embodiment of control system **100** is configured to control a conventional 5500 Soybean Special grain drill including two sections **300**. Each section **300** supports multiple (e.g., 12 and 12) row units **14** configured to apply seeds to a field. Seeds are metered by a seed module **16** on each section **300**. MIU **152** receives global command signals from CDU **140**, and returns monitored data. MIU **152** also receives speed signals used to calculate seeding data from sensor **302** coupled to the drill's wheels, and receives signals indicating whether implement **10** is up or down from sensor **304**. Application of products is disabled when implement **10** is raised.

Sensor bus **274** connects to a seed rate sensor **276** associated with each row unit **14**. MIU **152** monitors seed application rates using signals received from sensors **276**, and sends seed rate data to CDU **140**. Bus **274** is also coupled to bin level gateway modules **305** which monitor and receive bin level signals from bin level sensors **284** on each section **300**. Bin status data is transmitted to CDU **140** and connectors separate MIU **152** and sensors **276** and **284**.

Control system **100** may be upgraded by installing a removable MCC **154** on each frame section **300** to provide local variable-rate control. Referring to FIG. **8**, each MCC **154** includes interfaces **400–410** for implement bus **108**, on/off outputs **412** for driving valves, PWM outputs **414** for driving local product metering devices such as cyclo seed meter **32**, frequency inputs **416**, digital inputs **418**, and analog inputs **420**. Connections between MCC **154** and control system **100** are shown below. A processor (e.g., an AN80C196CB) coupled to memory circuits (e.g., RAM, EEPROM, Flash EPROM) provides control for MCC **154**.

Referring to FIGS. **9A–9C**, another embodiment of control system **100** further provides variable-rate control of the Cyclo Planter. In contrast to FIGS. **6A–6C**, MCCs **154** control the seed application rates of each section **300** based on rate command signals received from CDU **140** via bus **108**. Each MCC **154** converts the rate command signals into PWM control signals which are applied to a cyclo seed meter **32** (i.e., drum **34**) on seed module **16** (e.g., the PWM control signals are applied to a hydraulic valve assembly which regulates the flow of hydraulic fluid to motor **38**(. MCC **154** receives meter feedback speed signals from seed meter **32**, and communicates the meter speed feedback data back to CDU **140** for display. MCC **154** could also use the meter speed feedback signals for closed-loop metering control. Each MCC **154** also applies control signals to bin pressure or material flow sensor **288**, receives feedback signals from sensor **288**, and communicates bin pressure data back to CDU **140** for display.

Referring to FIGS. **10A–10B**, another embodiment of control system **100** further provides variable-rate control of the conventional drill. In contrast to FIGS. **7A–7B**, MCCs **154** control the rates at which seeds are applied by sections **300** using seed rate command signals received from CDU **140**. Each MCC **154** converts the rate command signals into rate control signals which are applied to a seed meter **32** on each seed module **16**. MCCs **154** receive feedback speed signals from meter **32**, and communicate meter speed data back to CDU **140** for display. MCCs **154** can also use the speed feedback signals for closed-loop metering control.

Referring to FIGS. **11A–11C**, control system **100** monitors the actual performance of implement **10** and shows actual performance data to the operator on display **202** of CDU **140**. To efficiently use the display, performance data for each section **300** of implement **10** is displayed sequentially. The location of the section **300** for which data is currently being displayed is labeled at reference numeral **500**. For example, FIGS. **11A–11B** and **11C** display performance data for the left, center and right sections **300**, respectively, of the Cyclo Planter of FIGS. **6A–6C** and **9A–9C**. The CDU screens for the drill of FIGS. **7A–7B** and **10A–10B** sequence between left and right sections **300**. The performance of implement **10** is scanned by showing data for each section **300** for a predetermined time period (e.g., 2 sec.) before showing data for the next section **300**. The sections are continually scanned. However, a touch-screen scan switch **502** allows the operator to pause the scan procedure on a selected section **300**, and to resume scanning. A second touch screen switch **504** is used to display seed spacing.

The displayed data includes the implement type **506** (e.g., "12/23 Cyclo"), product type **508** (e.g., "A" for product stored in bin a; "B" for product in bin B, etc.), section average rate **510** (e.g., average delivery rate of 29,100 s/acre across row units **14** of the left section), display identification **512** (e.g., "Rate"), implement speed **514** (e.g., "5.2 mph"), bin pressure **516** (e.g., "9.8 oz/si"), bin pressure controls **518** (e.g., "OFF" "+" and "–"), bin level **520**, menu bar **522** and bar graph **524**.

Implement type **506** may differ since control system **100** can be programmed for use with different implement types. Implement speed **514** is determined using signals from wheel speed sensors **302** (or radar **126**). Bin pressure controls **518** provide control over air pressure in module **16**. Bin level **520** displays the height of product in one or more bins **40**. Alarm **230** alerts the operator when the lowest bin level is reached. Menu bar **522** allows the operator to select the CDU mode, and includes a "MONITOR" touch-screen switch to select performance monitoring.

Based upon the sensed signals, control system **100** calculates and displays performance monitor data such as planting rate (Seed_Rate), seed spacing (Seed_Spacing), seed metering performance (Seed_Meter_Perf), percent singles metered (%_Singles_Metered), and accumulated metering performance (Accumulated_Meter_Perf). For each data item, CDU **140** displays a section average and a bar graph visually representing data for each row unit **14**.

Planting rate is defined as the actual amount of product (e.g., number of seeds) applied over an area (hectare or acre):

Seed_Rate=Seed_Sensor_Count/(Distance_Traveled*Row_Width)

wherein Seed_Sensor_Count is the number of seeds counted by seed sensors **276**, Distance_Traveled is the product of ground speed (sensed by wheel speed sensor **302**) and time, and Row_Width is the width between row units **14**. Seed spacing, displayed in response to actuations of switch **504**, is defined as the spacing (cm or in) between seeds:

Seed_Spacing=Distance_Traveled/Seed_Sensor_Count

Seed meter performance is defined as the actual seed delivery rate divided by a theoretical or target rate:

Seed_Meter_Perf=(Seed_Rate/Target_Seed_Rate)*100

wherein Target_Seed_Rate is the target seed rate based upon either a feedback speed signal from meter **32** (e.g., 5 sec average) and the arrangement of the seed drum, or upon the commanded seed planting rate. Percent singles metered is defined as the count from seed sensors **276** of metered seeds passing through seed tube **30** one at a time divided by the total number of seeds over an interval:

%_Singles_Metered=Counted_Singles/(Target_Seed_Rate*Distance_Traveled*Row_Width)

Accumulated meter performance is defined as an operator-resettable running average of the seed meter performance:

$$\text{Accumulated\_Meter\_Perf}_n=(\text{Accumulated\_Meter\_Perf}_{n-1}*(n-1)+\text{Seed\_Meter\_Perf})/n$$

The seed planting rate for n row units **14** of each section **300**, averaged over one second and five seconds, respectively, are as follows:

$$\text{Value}=(\Sigma\text{Seed\_Rate}_n)/n$$

$$\text{Section\_Average}_n=(\text{Value}_{n-4}=\text{Value}_{n-3}+\text{Value}_{n-2}+\text{Value}_{n-1}+\text{Value}_n)/n$$

The five-second section average ("Section_Average") is used for display (e.g. used for section average rate **510**), except that the current seed rate value ("Value") is used for the accumulated meter performance.

Bar graph **524** includes bars (e.g., bars **1–7** in FIG. **11**A; bars **1–8** in FIGS. **11**B and **11**C) showing the planting performance for row units **14** of each section **300** of the 12/23 Cyclo Planter. Five ranges along the vertical axis represent 85%, 90%, 95%, 100% and 105% of a target seed delivery rate, with 100% of the target rate marked by a horizontal line **526**. The target rate, set manually or automatically based upon the implement position a d a prescription map, may differ for each section **300** during variable-rate application. For example, the target rate is 30,000 s/acre for the left and right sections (FIGS. **11**A and **11**C) and 28,500 s/acre for the center section (FIG. **11**B). Actual delivery rates for row units **14** are shown by the bars on graph **524**. Row unit **1** of the left section, for example, has applied seed at an actual rate of 31,500 s/acre. Displaying the actual rate based upon the target rate normalizes the actual seed delivery rate. Thus, bar graph **524** is an easily understood performance monitor for each section and row unit of implement **10** since deviations in rates are represented by differences between horizontal line **26** and the actual rate markers. An operator noticing large deviations between actual and target seed rates can re-adjust or repair implement **10**.

Other application parameters calculated by control system **100**, and displayed on CDU **140**, include the total area (Hectares or acres) the system has monitored during its lifetime, the total area monitored during the season, and the total area monitored in the field. The lifetime area counter is non-resettable, while the season area and field area counters are resettable by the operator. The implement performance is monitored during application of seed, and is enabled when the implement status switch **304** indicates that implement **10** is down and the ground speed exceeds a predetermined value (e.g., 0.22 meter/sec.).

While the embodiments illustrated in the FIGURES and described above are presently preferred, it should be understood that these embodiments are offered by way of example only. The control system disclosed herein may be modified for use on other planters, conventional or air drills, other planting implements and material spreaders having variable-rate control, and other electronically-controlled application implements. The invention is not intended to be limited to any particular embodiment, but is intended to extend to modifications that nevertheless fall within the scope of the claims.

What is claimed is:

1. A seed planting system for planting seed in soil at desired rates, the system comprising:

a tractor including an operator station;

a seed planter including a seed channel having an exit through which a number of seeds move toward the soil, and a singulating seed meter for singulating seed and delivering the singulated seed to the seed channel;

an electronic seed sensor attached to the seed planter to generate a seed signal representative of the number of seeds;

an electronic display supported at the operator station, the display generating images in response to display signals;

at least one operator-activated control supported at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator-activated control, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed planter which affects the singulating accuracy of the singulating seed meter in response to activation of the operator-activated control.

2. The system of claim **1**, wherein the channel is defined by a tube through which the seeds are delivered toward the soil.

3. The system of claim **2**, wherein the seed sensor changes a value of the seed signal in response to the passage of a seed through the seed channel.

4. The system of claim **3**, wherein the seed meter includes a seed drum and a mechanism oriented relative to the seed drum to disperse seeds within the seed drum and the parameter is representative of the orientation of the mechanism relative to the seed drum.

5. The system of claim **3**, wherein the display is an LCD display.

6. The system of claim **3**, wherein the seed planter includes an air source for pressurizing the singulating seed meter with an air flow and the parameter is representative of the air flow.

7. A seed planting monitoring system useable with a planting arrangement having an operator station, a seed delivery system having a target seed delivery rate controlled by at least one control signal, a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, and a singulating seed meter for singulating seed and delivering the singulated seed to the seed channel, the system comprising:

an electronic seed sensor attachable to the seed delivery system to generate a seed signal representative of the number of seeds;

an electronic display adapted to be supported at the operator station, the display generating images in response to display signals;

an operator interface located at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator interface, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed delivery system which affects the singulating accuracy of the singulating seed meter in response to activation of the operator interface.

8. The system of claim **7**, wherein the processing circuit generates and applies the control signal to the seed delivery system, and applies the display signal to the display such that the image is also representative of the target seed delivery rate.

9. The system of claim **8**, wherein the channel is located in a tube through which the seeds are delivered toward the soil.

10. The system of claim **9**, wherein the seed sensor changes a value of the seed signal in response to the passage of a seed through the seed channel.

11. A seed planting system for planting seed in soil at desired rates, the system comprising:

a tractor including an operator station;

a seed planter including a seed channel having an exit through which a number of seeds move toward the soil, wherein the channel is defined by a tube through which the seeds are delivered toward the soil, wherein the seed planter includes a delivery control mechanism including an air source for moving the seed through the tube with an air flow and a parameter of the seed planter is representative of the air flow;

an electronic seed sensor attached to the seed planter to generate a seed signal representative of the number of seeds, wherein the seed sensor changes a value of the seed signal in response to the passage of a seed through the seed channel;

an electronic display supported at the operator station, the display generating images in response to display signals;

at least one operator-activated control supported at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator-activated control, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed planter which affects the actual seed delivery rate in response to activation of the operator-activated control.

12. A seed planting system for planting seed in soil at desired rates, the system comprising:

a tractor including an operator station;

a seed planter including a seed channel having an exit through which a number of seeds move toward the soil, wherein the channel is defined by a tube through which the seeds are delivered toward the soil;

an electronic seed sensor attached to the seed planter to generate a seed signal representative of the number of seeds, wherein the seed sensor changes a value of the seed signal in response to the passage of a seed through the seed channel;

an electronic display supported at the operator station, the display generating images in response to display signals;

at least one operator-activated control supported at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator-activated control, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed planter which affects the actual seed delivery rate in response to activation of the operator-activated control, wherein the image includes a bar graph including bars representative of the actual seed delivery rate and a desired seed delivery rate.

13. A seed planting system for planting seed in soil at desired rates, the system comprising:

a tractor including an operator station;

a seed planter including a seed channel having an exit through which a number of seeds move toward the soil, wherein the channel is defined by a tube through which the seeds are delivered toward the soil;

an electronic seed sensor attached to the seed planter to generate a seed signal representative of the number of seeds, wherein the seed sensor changes a value of the seed signal in response to the passage of a seed through the seed channel;

an electronic display supported at the operator station, the display generating images in response to display signals;

at least one operator-activated control supported at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator-activated control, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed planter which affects the actual seed delivery rate in response to activation of the operator-activated control, wherein the image includes a bar graph including a bar representative of the actual seed delivery rate and referenced to a desired delivery rate.

14. A seed planting monitoring system useable with a planting arrangement having an operator station, a seed delivery system having a target seed delivery rate controlled by at least one control signal, and a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, the system comprising:

an electronic seed sensor attachable to the seed delivery system to generate a seed signal representative of the number of seeds;

an electronic display adapted to be supported at the operator station, the display generating images in response to display signals;

an operator interface located at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator interface, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed delivery system which affects the actual seed delivery rate in response to activation of the operator interface, wherein the processing circuit generates and applies the control signal to the seed delivery system, and applies the display signal to the display such that the image is also representative of the target seed delivery rate, wherein the image includes a bar graph including bars representative of the respective target and actual seed delivery rates.

15. A seed planting monitoring system useable with a planting arrangement having an operator station, a seed delivery system having a target seed delivery rate controlled by at least one control signal, and a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, the system comprising:

an electronic seed sensor attachable to the seed delivery system to generate a seed signal representative of the number of seeds;

an electronic display adapted to be supported at the operator station, the display generating images in response to display signals;

an operator interface located at the operator station; and

a digital processing circuit coupled to the seed sensor, the display and the operator interface, wherein the processing circuit monitors the seed signal, determines an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored, applies a display signal to the display to generate an image representative of the actual seed delivery rate, and modifies a parameter of the seed delivery system which affects the actual seed delivery rate in response to activation of the operator interface, wherein the processing circuit generates and applies the control signal to the seed delivery system, and applies the display signal to the display such that the image is also representative of the target seed delivery rate, wherein the image includes a bar graph including a bar representative of the actual seed delivery rate and referenced to the target seed delivery rate.

16. The system of claim **15**, wherein the planting arrangement includes a tractor, the seed delivery system is coupled to the tractor, and the operator station is a cab supported by the tractor.

17. A method of maintaining a seed planting rate of a seed planter from a cab of a tractor, the planter including a seed delivery system having a target seed delivery rate controlled by at least one control signal, a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, and a singulating seed meter for singulating seed and delivering the singulated seed to the seed channel, the method comprising the steps of:

generating a seed signal representative of the number of seeds;

applying the at least one control signal to the seed delivery system to control the target seed delivery rate;

monitoring the seed signal to determine an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored;

generating a display signal representative of the actual seed delivery rate;

applying the display signal to an electronic display located in the cab to generate an image on the display representative of the actual seed delivery rate; and

modifying a parameter of the seed delivery system which affects the singulating accuracy of the singulating seed meter in response to activation of an operator-activated control input.

18. The method of claim **17**, wherein the display signal also represents the target seed delivery rate, and the image also represents the target seed delivery rate.

19. The method of claim **17**, wherein the step of generating a seed signal includes monitoring the seeds at the exit to generate the seed signal.

20. A method of maintaining a seed planting rate of a seed planter from a cab of a tractor, the planter including a seed delivery system having a target seed delivery rate controlled by at least one control signal, and a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, the method comprising the steps of:

generating a seed signal representative of the number of seeds;

applying the at least one control signal to the seed delivery system to control the target seed delivery rate;

monitoring the seed signal to determine an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored;

generating a display signal representative of the actual seed delivery rate, including configuring the display signal to generate an image on the display including a bar graph having bars representative of the respective target and actual seed delivery rates;

applying the display signal to an electronic display located in the cab to generate an image on the display representative of the actual seed delivery rate; and

modifying a parameter of the seed delivery system which affects the actual seed delivery rate in response to activation of an operator-activated control input.

21. A method of maintaining a seed planting rate of a seed planter from a cab of a tractor, the planter including a seed delivery system having a target seed delivery rate controlled by at least one control signal, and a seed channel having an exit through which a number of seeds move toward soil in which the seeds are planted, the method comprising the steps of:

generating a seed signal representative of the number of seeds;

applying the at least one control signal to the seed delivery system to control the target seed delivery rate;

monitoring the seed signal to determine an actual seed delivery rate based upon the number of seeds and a time period during which the seed signal is monitored;

generating a display signal representative of the actual seed delivery rate, including configuring the display signal to generate an image on an electronic display including a bar graph having at least one bar representative of the actual seed delivery rate and referenced to the target seed delivery rate;

applying the display signal to the display located in the cab to generate an image on the display representative of the actual seed delivery rate; and modifying a parameter of the seed delivery system which affects the actual seed delivery rate in response to activation of an operator-activated control input.

22. A metering system for selectively applying material to the soil of an agricultural field, the system comprising:

a tractor including a cab;

a singulating material meter coupled to the tractor for towing by the tractor and including a material channel having an exit through which an amount of singulated material moves toward the soil;

an electronic sensor supported relative to the meter to generate a material signal representative of the amount of material;

an electronic display supported within the cab to generate images in response to display signals;

at least one operator-activated control supported at the cab; and

a processing circuit coupled to the sensor and the display, wherein the processing circuit monitors the material signal, determines an actual material delivery rate based upon the amount of material and a time period during which the material signal is monitored, applies a display signal to the display to generate an image representing the actual material delivery rate, and modifies a parameter of the meter which affects its singulating accuracy on activation of the operator-activated control.

23. The system of claim **22**, wherein the channel is defined by a tube through which the material is delivered toward the soil.

24. The system of claim **23**, wherein the material is seed and the amount of material is a number of seeds.

25. The system of claim **23**, wherein the sensor changes the material signal in response to the passage of amounts of material through the material channel.

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